POWER PLANT ENGINEERING

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Power and Heating Plant of Utica State Hospital

MECHANICAL NEEDS OF INSTITUTION APPROACHING CITY PROPORTIONS SUPPLIED FROM CENTRAL PLANT

AT MARCY, N. Y., a few miles out of the city of Utica, is a site covering 1035 acres chosen by state authorities for the new insane hospital which is known as the Marcy Division of the Utica State Hospital. When the present plans are completed this institution will consist of 52 buildings, including the cottages occupied by the employes, and will supply the needs of 3000 patients. This institution will form a fair sized town and it has all been laid out to give the greatest possible convenience and comfort to those who will reside there.

One of the first buildings to be constructed was the power plant, the services of which are extremely valuable in completing the construction of other buildings of the institution, three of the largest of which are now nearing completion. All the buildings and cottages will be heated from the power plant by forced hot water circulation, the main pipes being carried in a concrete tunnel 8½ ft. wide by 10 ft. high and 3100 ft. long, with laterals carried to the buildings in Johns-Manville conduits.

Not only will the power plant furnish heat but light, power and refrigeration. Steam at reduced pressure will be supplied for cooking, sterilizing, laundry and other purposes. Water for domestic use will be heated in the power plant and kept in continuous circulation by pumps. Although the pumping plant for the institution is separated from the power plant it comes under the supervision of the chief engineer, T. J. Williams,

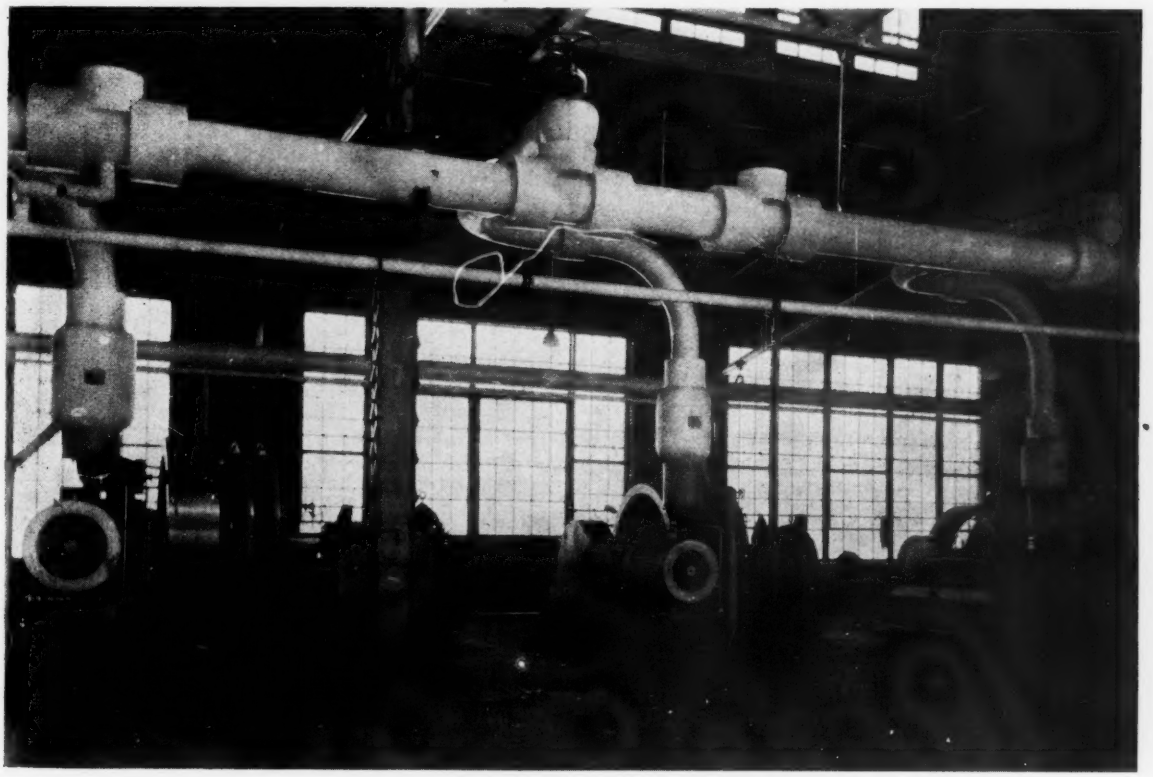


FIG. 1. GENERATING UNITS AT UTICA STATE HOSPITAL

and the power required is drawn from the generators in the power plant.

To supply water for the institution a dam was constructed across a creek, thus forming a large reservoir from which the water is drawn, filtered, purified and delivered to a water tower on a hill.

The various plans for the institution were worked out under the direction of L. F. Pilcher, state architect, former Chief Engineer Nichols and the present Chief Engineer, R. C. Taggart, being responsible for the design of the power plant, which is in reality a central station supplying practically all the mechanical needs of the entire institution. The mechanical equipment in the power plant was installed by the Shevlin Engineering Co., Langdon & Hughes, General Electric Co. and the Ridgeway Engine & Dynamo Co.

General Arrangement of Power Plant

For convenience in securing rail deliveries of coal and machinery, the power plant building is located near the railroad track with a private siding provided with a track hopper for receiving coal from drop-bottom cars. In general, the building consists of a boiler house with basement, separated by a fire wall from a heater and pump room through which an elevated aisle passes from the main floor of the boiler house to a mezzanine floor on which are located the generators and where provision is made for the refrigerating machinery which will be installed later. Beyond the engine room is a large machine room separated from the rest of the building by a fire wall and used at present as a garage. The entire structure is of brick and steel, well provided for natural lighting with large windows in the side walls and roof.

Coal which is used in the plant is Pennsylvania bituminous run-of-mine which has an average heat value of 14,600 B.t.u. and an ash content of 8 per cent. From the track hopper an apron feeder delivers the coal to a double roll crusher whence it is discharged to a bucket conveyor through an automatic bucket filling valve which operates in such a way as to deliver to each bucket the correct amount of coal without spilling over the edges.

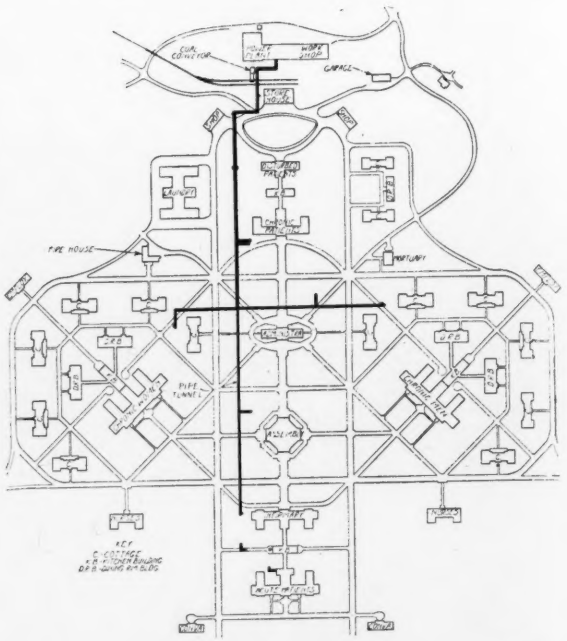


FIG. 2. PLAT SHOWING LOCATION OF HOSPITAL BUILDINGS AND PIPE TUNNEL

Separate General Electric Co. motors are employed for driving the crusher and the conveyor, each having a rating of 25 hp. at 220 v., using 3-phase current of 60 cycles frequency. A special device prevents the crusher motor from starting until the conveyor is at full speed and can carry the coal away as fast as it is received. By means of this equipment a carload of 70 T. can be handled in 20 min.

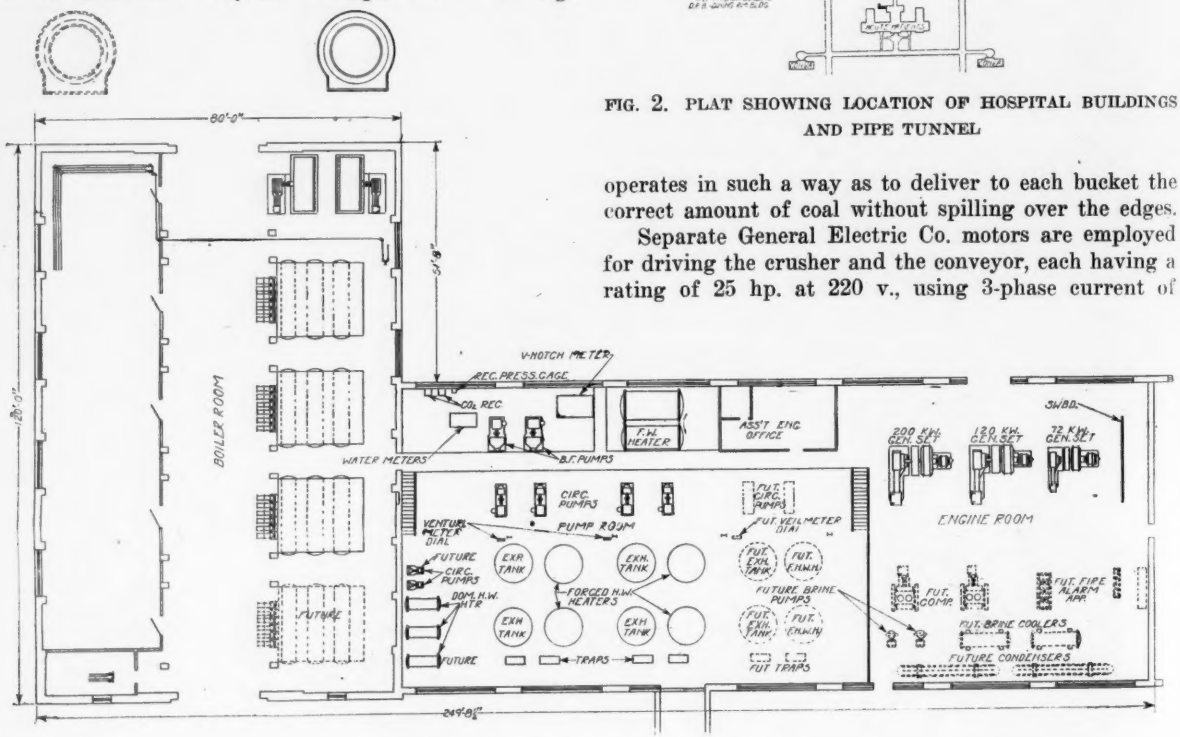


FIG. 3. MAIN FLOOR PLAN OF POWER PLANT

Delivery of the coal from the conveyor is to an 800-T. reinforced concrete bunker, built by the Brown Hoisting Machinery Co., located over the firing aisle in the boiler room. Gates in the bottom of the bunker discharge to a traveling weigh larry which has chutes to stoker hoppers on each side of the aisle. The larry is equipped with Fairbanks scales which stamp the weights on cards.

Ashes discharged from the stokers are quenched with water in the ashpit then dumped into industrial cars for delivery on tracks to a ship hoist. Soot accumulation in the combustion chambers is delivered through chutes to the same cars and disposed of with the ashes. The ash bin to which the skip hoist delivers the ashes is located outside the building and elevated to such a height that trucks may pass under it to receive the ashes by gravity through a gate in the bottom of the bin.

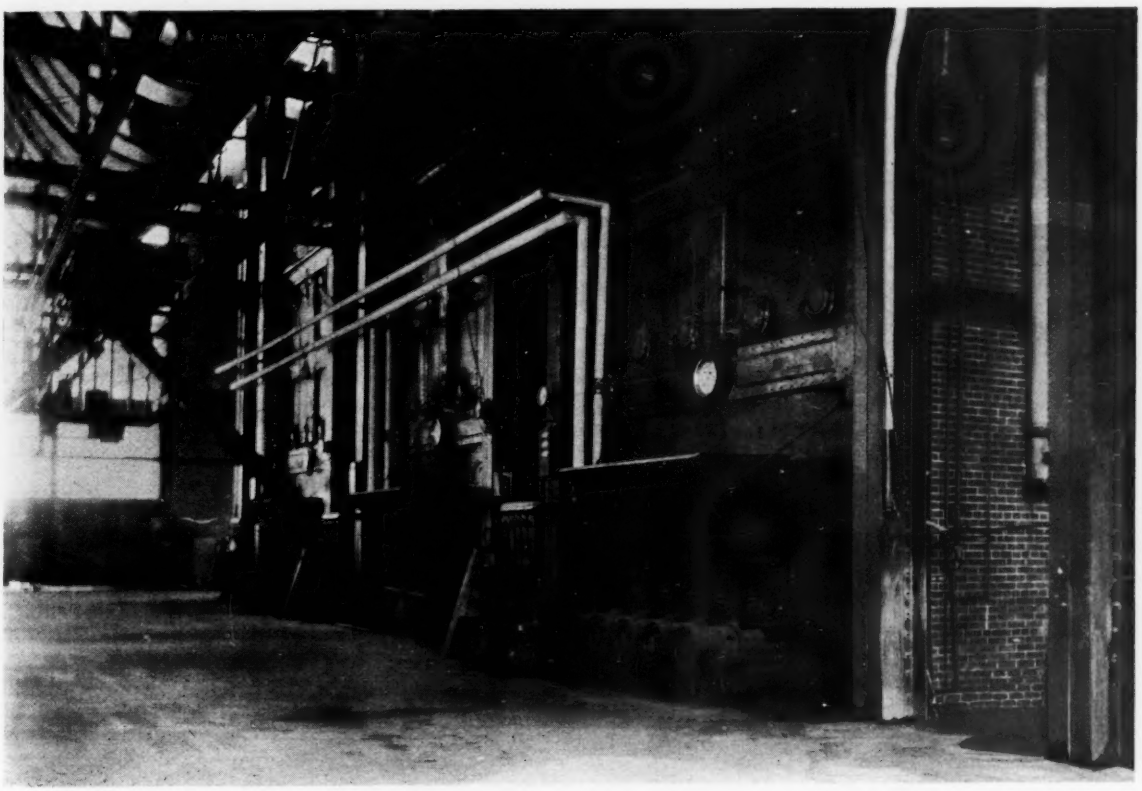


FIG. 4. LOOKING DOWN FIRING AISLE IN BOILER ROOM

Boiler Room

In the design of the boiler room considerable attention was given to arranging the equipment so that natural light would be used as much as possible. This was accomplished partly by placing large windows in the ends of the boiler room and partly by elevating the coal bunker so that light will be let in to the firing aisle from the windows above the boilers. Light at night is supplied by a number of 1000-w. electric lights advantageously located around the room.

Although the ultimate plans call for eight boilers, at the present time there are only three of them installed. Each of these has a rating of 500 hp. and is supported in a single setting. They are Stirling boilers and are operated at 125 lb. pressure, which is indicated by an Ashcroft pressure gage, a record being made of the header pressure on a Columbia recording pressure gage. Water level in the boiler is controlled by feed water regulators, and the Reliance water column has a high and low level alarm attachment. Each boiler is provided with two blowoff pipes which connect by a Y fitting to the main pipe leading to the blowoff chamber. In each branch and main pipe is an Everlasting blowoff valve. For dusting the boiler tubes of soot, Diamond soot blowers are employed.

Serving the boilers are Jones A. C. 5-retort underfeed stokers the operation of which is automatically controlled in unison with the load on the boilers by means of a Gardner governor which also controls the speed of the two fan engines furnishing the forced draft for the stokers. These fan units consist of Victory 11 by 10-in. engines direct connected to No. 170 Clarage fans. The normal speed of these units is 300 r.p.m., but varies with the load carried on the boilers so as to furnish the proper amount of air for the coal being burned. The amount of steam being generated is shown by flow meters, one of which is installed in the lead from each boiler.

Although, as stated above, the forced draft is automatically controlled, draft over the fire is regulated by manually operated dampers in the connections to the breechings, the hand levers being conveniently located at the front of the boilers. In making damper adjustments, the firemen are guided by the indications of a three-in-one draft gage, provided for each boiler, which gives the air pressure under the fuel bed, draft in the

furnace and at the damper. The correctness of combustion is shown by a recording CO_2 instrument taking samples of the gas at the entrance to the stack. Aid is also given the firemen in handling the boilers by the

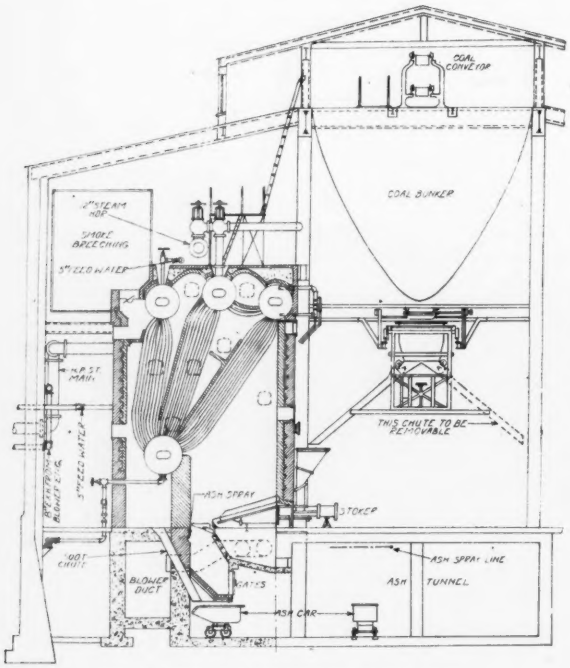


FIG. 6. SECTION THROUGH BOILER ROOM

located just outside the boiler room wall in line with the rear of the boilers now installed. Future plans call for another stack of like dimensions to care for the gases from the boilers to be installed on the other side of the aisle.

Water used for feeding the boilers is principally the returns from the heating system, make-up water being taken from the regular institution supply system through a meter. Return condensate from the heating system and the high and low pressure drip piping together with the make-up water go to the Cochrane open feed water heater to which is connected an auxiliary storage tank which was provided to prevent waste of hot condensate returns when these exceed the demand for feed water.

Exhaust steam from the engines and auxiliaries is used for heating the feed water, that from the engines first passes through an oil separator. In order to reduce the flow of steam through the separator the size of the exhaust pipe is increased from 10 in. to 14 in. for a run of 14 ft. before entering the 14-in. oil separator. This arrangement is an insurance against oil in the exhaust steam which is used not only for heating feed water but also for heating domestic water and that used in the heating system.

Leaving the heater at a temperature around 210 deg. F., the feed water passes through a Cochrane V-notch meter on its way to the feed pumps on the floor below. Two Dayton-Dowd Co. three-stage centrifugal boiler feed pumps are installed; these are driven by direct connected 45-hp. Terry turbines run at 2500

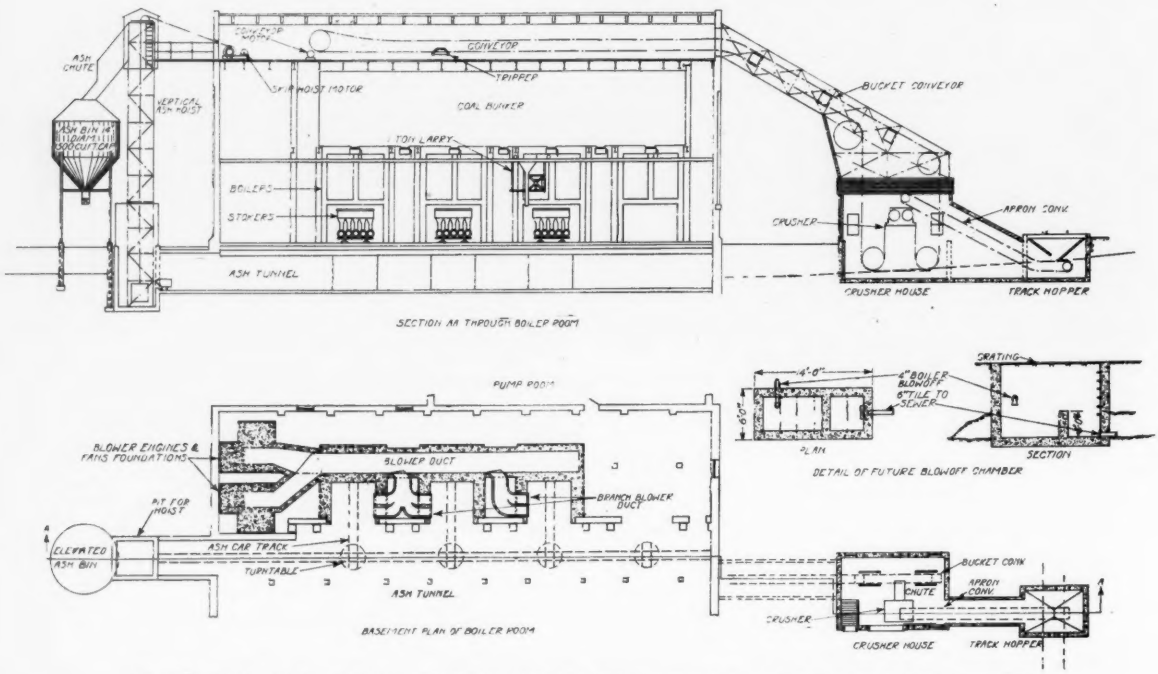


FIG. 5. DIAGRAM OF COAL AND ASH HANDLING EQUIPMENT; PLAN OF BOILER ROOM BASEMENT

recording pyrometer giving the temperature of the stack gases.

Natural draft for the removal of the flue gases is induced by a radial brick stack 150 ft. high, 13 ft. in diameter at the bottom and 10 ft. at the top. This is

r.p.m. and are designed to deliver 400 gal. per min. against a pressure of 140 lb. which is maintained constant by means of a pump governor. All boiler feed piping is extra heavy, galvanized and lead lined.

Throughout this entire plant one is impressed with

the appearance of the steam piping which is covered throughout with magnesia held in place by a layer of canvas, even the flanges and valve bodies are fitted with molded covering which may be easily removed in case of trouble. The covering is painted white, no color designation being employed, but at short distances on each pipe are stenciled in black letters the services to which the pipes are put. All high pressure piping is extra heavy with steel flanges and Vanstone joints.

Leads from the boilers take the form of a loop to the header, an automatic stop and check valve being placed at the boiler opening and a hand operated angle valve at the header which runs parallel with the line of the boilers. From this header the main steam line is taken off at right angles and extends the entire length of the pump and engine room with branches taken off on each side for supplying equipment requiring live steam.

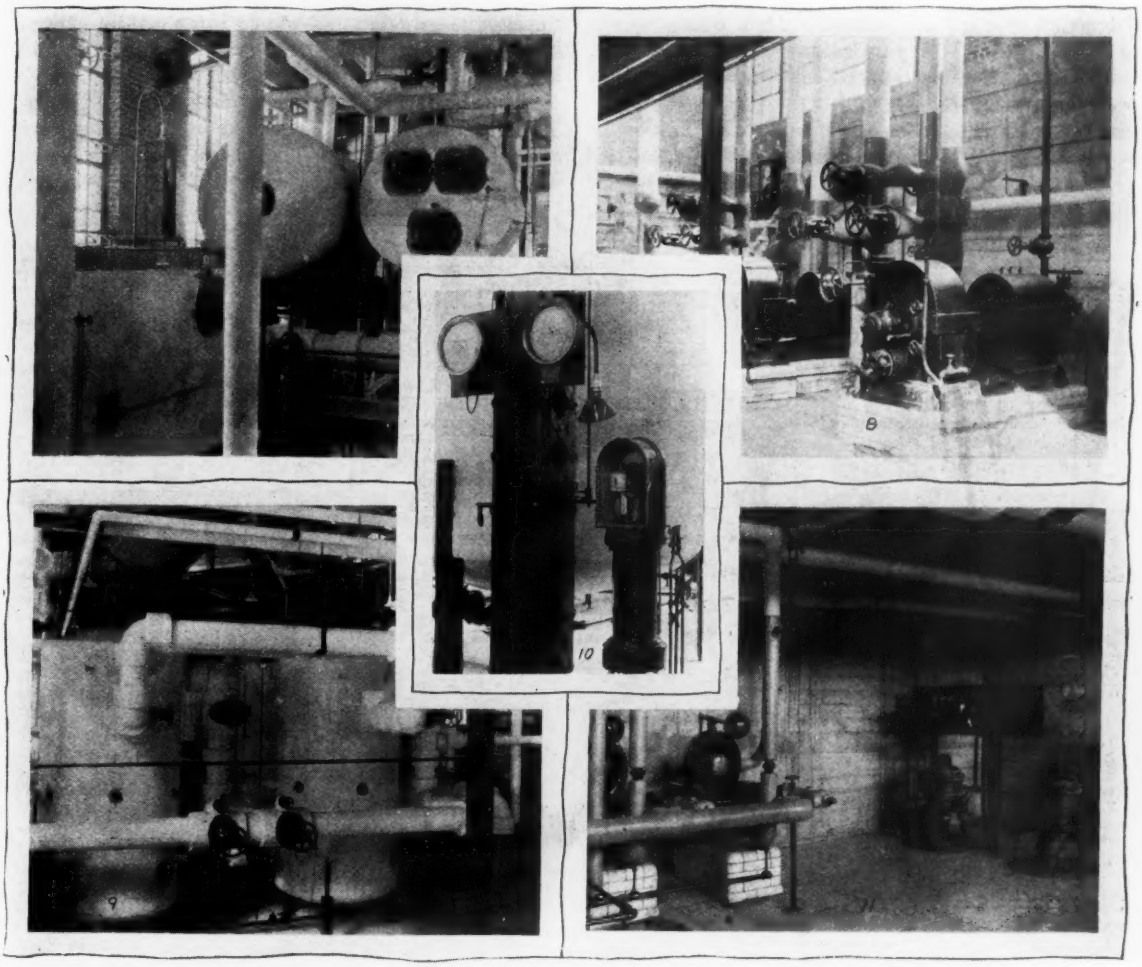


FIG. 7. FEED WATER HEATER, AUXILIARY TANK AND METER. FIG. 8. TURBINE DRIVEN BOILER FEED PUMPS. FIG. 9. WATER HEATERS FOR HEATING SYSTEM. FIG. 10. THERMOMETERS AND FLOW METER FOR ONE UNIT OF HEATING SYSTEM. FIG. 11. RETURN TRAPS FOR EXHAUST STEAM PIPING; SUMP PUMP

Electric Generating Units

Three electric generating units furnish the needs of the entire institution for light and power. These are all Ridgway engines direct connected to alternating current generators delivering 3-phase current at a frequency of 60 cycles and 2400 v. Each unit has its own exciter direct connected to the shaft, the exciter voltage in all cases being 125.

Unit No. 1 consists of a 312-hp. engine, with a cylinder 19 in. in diameter by 20 in. stroke run at 200 r.p.m., the generator is rated at 250 kv.a. or 200 kw. at 80 per cent power factor and the exciter has a capacity of 12½ kw.

The second unit is driven by an engine 15 by 16 in., rated at 200 hp. and runs at 257 r.p.m., while the generator is rated at 120 kw. and the exciter at 8 kw.

The engine driving No. 3 unit runs at 277 r.p.m., is rated at 120 hp. having a cylinder 12 by 14 in. The rating of the generator is 72 kw., and that of the exciter 7 kw.

For controlling the output of the generators, a standard General Electric switchboard is installed consisting of 10 panels, located near the end wall of the engine room, adjacent to unit No. 3. Current is distributed throughout the institution at 2300 v., 3-phase, the voltage being stepped down at the various buildings to suit the needs.

In the power plant, motors operate at 200 v. on 3-phase current and the lights at 110 v., this current is supplied through two General Electric Co. single phase

transformers tied together by a Scott connection, one being rated at 37½ kv.a., the other at 25. These are located in a compartment off the pump room under the engine room floor.

Heating System

As has already been stated, the buildings constituting the institution are all heated by hot water, the circulation being forced through pipes in tunnels and conduits by pumps located in the power plant. The water used in this system is heated by the exhaust steam from the main engines and all steam driven auxiliaries supplemented by live steam at reduced pressure when the demands require it. Exhaust steam comes to the heaters at a pressure ranging from atmospheric to 5 lb. while the live steam is reduced in pressure from that carried in the header to 10 lb.

At present there are installed two heating units with provision made for one more, each unit consisting of two heaters; two expansion tanks; two turbine driven, two-stage centrifugal circulating pumps rated at 2250 gal. per min. and run at 1800 r.p.m.; and two Bundy steam traps, together with instruments.

The heaters are of the vertical flue type, taking the form of a closed heater, and were built by the Geneva Manufacturing Co. They are so connected that both may use either exhaust or live steam at reduced pressure of 10 lb. or one uses exhaust steam while the other takes live steam, a check valve being provided to prevent live steam from backing up in the exhaust piping. The condensate that accumulates is drawn off by the Bundy return traps. These have 3-in. connections and deliver the condensate to the feed water heater while it is still hot, the elevation being about 20 ft. Steam from the intermediate pressure piping, at about 20 lb., is used in the traps for returning the water.

Water used for circulating through the radiators leaves the plant under the conditions prevailing during the past winter, at about 178 deg. F. and returns at 172 deg. It may be passed through the heaters in parallel or in series, or either one may be bypassed. Circulation of the water through the system may be varied to suit weather conditions by varying the speed of the turbines driving the pumps, in the steam supply line to which is an adjustable pressure reducing valve.

For each unit a separate pipe line is run in the tunnel, the outgoing and return pipes being of the same size, 12 in. in diameter. They carry 50 lb. pressure and are made up of extra heavy piping with Vanstone joints well insulated with 85 per cent magnesia pipe covering. The amount of water circulated in each unit is registered by a Simplex flow meter and Columbia recording thermometers give the outgoing and return water temperatures.

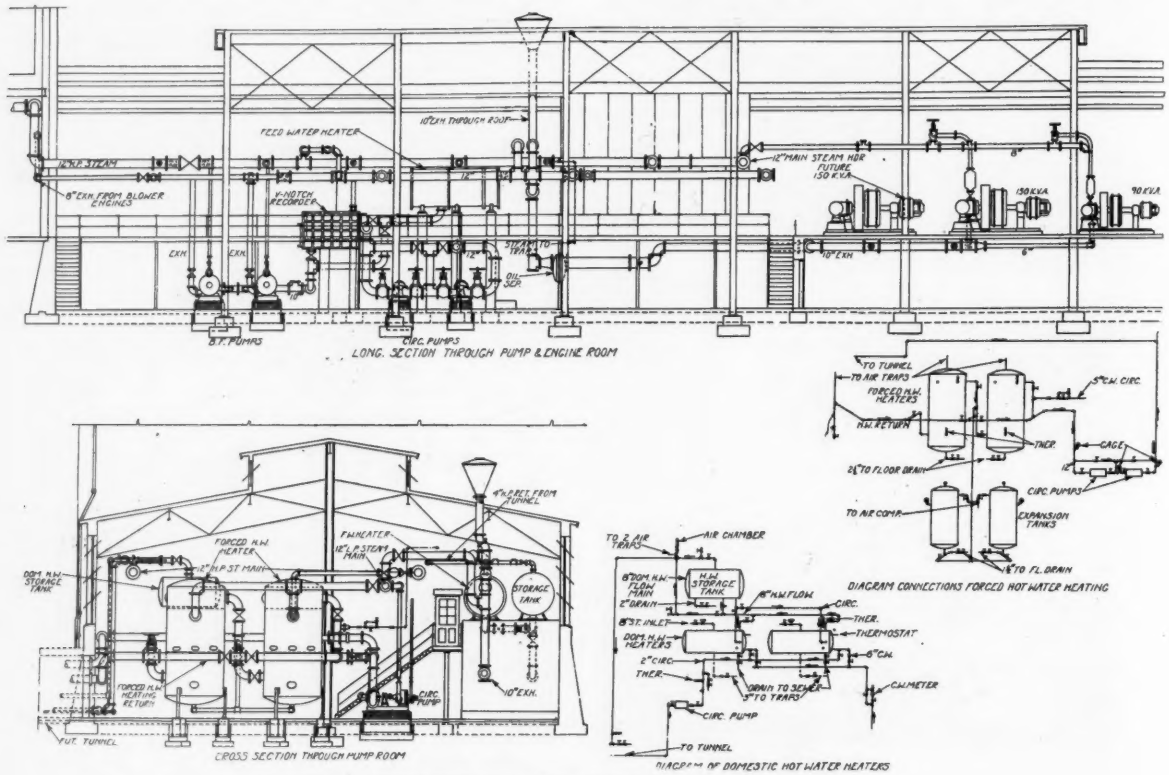


FIG. 12. CROSS SECTIONS AND DIAGRAMS OF PIPING SYSTEMS

The heaters are so connected that both may use either exhaust or live steam at reduced pressure of 10 lb. or one uses exhaust steam while the other takes live steam, a check valve being provided to prevent live steam from backing up in the exhaust piping. The condensate that accumulates is drawn off by the Bundy return traps. These have 3-in. connections and deliver the condensate to the feed water heater

In connection with each heater is an expansion tank the upper part of which is filled with air at 50 lb. pressure supplied by a Westinghouse two-stage vertical air compressor. The tank is provided with a relief valve which opens in case the water being circulated in the system expands under heat to such an extent as to increase the pressure beyond the desired limit. Make-up water comes directly from the service system through an integrating meter.

Hot water used for domestic purposes is heated in two Whitlock heaters by exhaust or reduced pressure live steam as the conditions demand. Connected to

the heaters is a storage tank that will take care of fluctuating demands. The temperature is maintained at 120 to 140 deg. F. by a Powers temperature control valve. This hot water is kept in circulation by a Dayton-Dowd single-stage centrifugal pump rated at 50 g.p.m. and driven at 1150 r.p.m. by a 1½-hp. Wagner motor. The hot water main in the tunnel consisting of an outgoing and a return pipe is made up of 8-in. extra heavy galvanized pipe.

The tunnel also accommodates the intermediate pressure steam piping, used for cooking, sterilizing, laundry work, etc., which consists of two 4-in. outgoing lines and one 4-in. line returning the condensate. The pressure carried on these lines is 40 lb., the steam being obtained through reducing valves from the main header.

All high pressure steam piping in the plant is well provided with drip pockets from which the condensate is removed and delivered to the feed water heater by means of Johns-Manville ball traps. Condensate from the low pressure piping which does not contain oil is pumped up to the heater by the two Bundy return traps shown in Fig. 11, which also shows the two Yeomans Bros. Co. sump pumps which automatically deliver sewage collected in the plant to a sewage disposal plant and then into the state barge canal. Clear water drainage from the plant runs by gravity to the creek below the dam.

Pumping Plant

By building a reinforced concrete dam, 30 ft. high and 650 ft. long, across the creek a reservoir was formed which has a total capacity of 50,000,000 gal. but which gives 20,000,000 gal, as the working capacity. From the dam reservoir the water runs by gravity to a clarinating station where it is first treated with alum, then passed through the Roberts filtering beds, of which there are four, each having a rated capacity of 200 gal, per min.

Each filter has a loss of head meter and when the reading shows an excessive head loss, the filtering bed consisting of various sizes of crushed quartz is back

Principal Equipment in Power Plant

No.	Equipment—	Service, Type—	Manufacturer—
1	Air compressor	Air to expansion tanks	Westinghouse Air Brake Co.
3	Ash hopper plates		Utica Steam Boiler Co.
3	Boilers, Stirling	500 hp., 125 lb. pressure	Babcock & Wilcox Co.
	Boilers, brickwork	Individual settings	Geo. Allen & Sons.
2	Boiler feed pumps	Centrifugal, turbine drive	Dayton-Dowd Co.
	Back pressure valves	To maintain from 5 to 10 lb. exhaust steam pres. on heating system	Atwood & Morrill.
3	Boiler feed water regulators	Continuous feed	S-C Regulator Mfg. Co.
2	Boiler feed pump regulators	Maintains 140 lb. on feed line	S-C Regulator Mfg. Co.
	Boiler tube cleaner	Water turbine drive	Roto Co.
	Breeching	Boilers to stack	Geneva Boiler Works.
	Coal and ash handl'g apparatus.	3-roll crusher, apron conveyor, bucket conveyor, industrial ash cars, ship hoist	C. W. Hunt Co.
1	CO_2 recorder	Analyzing stack gases	Precision Instr. Co.
1	Hot water pump	Circulating domestic hot water. Centrifugal, motor driven. 50 g.p.m.	Dayton-Dowd Co.
2	Domestic hot water heaters	Heating water used for domestic purposes, closed type using exhaust or reduced pressure live steam	Whitlock Coil Pipe Co.
3	Draft gages	3-in-1, pressure in wind box, draft in furnace and at damper	Precision Instr. Co.
3	Engines	Driving generators	Ridgway Dynamo & Engine Co.
2	Engines	Driving draft fans	Erie Engine Works.
1	Feed water heater	Open, Cochrane	H. S. B. W.-Cochrane Corp.
1	Feed water meter	V-notch	H. S. B. W.-Cochrane Corp.
	Fittings, pipe	Flange and screw	General Fire Extinguisher Co.
	Gage tester	Adjusting instruments	Amer. Steam Gauge & Valve Mfg. Co.
	Gages	Pressure indicating	Marshalltown Mfg. Co.
	Gages	Air pressure tank	Marshalltown Mfg. Co.
3	Generators	3-phase, a.c., 2400 v.	General Electric Co.
4	Water heaters	Heating system	Geneva Mfg. Co.
3	Steam flow meters	Measuring boiler output	Republic Flow Meters Co.
	Oil separator	Oil from exhaust steam	H. S. B. W.-Cochrane Corp.
	Pipe covering	Steam and hot water piping—magnesia	Johns-Manville, Inc.
	Pressure reducing valves	Low pressures	Atwood & Morrill.
	Pipe	Flanged	Ballwood Co.
	Pipe	Random lengths	LaBelle Iron & Steel Co.
	Pipe	Lead lined	United Lead Lined Pipe Co.
	Packing	Steam and water	Garlock Packing Co.
	Pyrometer	Recording flue gas temperatures	Brown Instrument Co.
	Radiators	Single pipe, sectional	H. B. Swartout Co.
3	Steam separators	Leads to generating units	Crane Co.
3	Soot blowers	Mechanical—in boiler settings	Diamond Power Spec. Corp.
3	Stokers	Jones a.c. underfeed	Underfeed Stoker Co. of America.
1	Steam pressure gage	Recording header pressure	Schaeffer & Budenberg Mfg. Co.
6	Steam turbines	2 driving boiler feed and 4 variable speed for heating water circulating pumps, speed varied to meet temperature conditions	Terry Turbine Co.
2	Steam pumps	Vertical automatic, sewage disposal	Yeomans Bros. Co.
	Temperature regulating valves	Domestic hot water heaters	Powers Regulator Co.
	Traps, steam	Returning low pressure condensate to heater—Bundy	Bundy Steam Trap Co.
	Traps, steam	Nonreturn, delivering high pressure drips to heater	Johns-Manville, Inc.
4	Tanks	Expansion and storage in heating system	New York Central Iron Wks.
4	Thermometers	Recording heating water temperature	Schaeffer & Budenberg Mfg. Co.
	Thermometer	12-in. dial, 7-day type	Schaeffer & Budenberg Mfg. Co.
	Thermometers	9 to 12 in., indicating	Schaeffer & Budenberg Mfg. Co.
	Traps, air	½-in. vertical, ball float type	Wright-Austin Co.
2	Meters	Recording water flow in heating system	Simplex Valve & Meter Co.
	Valves	Gate and check	Chapman Valve Mfg. Co.
	Valves	Globe and angle	Jenkins Bros.
	Valves	Stop and check	Jenkins Bros.
	Valves	Water relief	Amer. Steam Gauge & Valve Mfg. Co.
2	Water meters	Disc type, measuring water taken from institution supply	Worthington Pump & Machy. Co.

washed by means of a single stage, double suction, Morris centrifugal pump driven by a 30-hp. motor at 173 r.p.m.

From the filter beds the water flows by gravity to a covered clear water basin which has a capacity of 50,000 gal. Taking the water from this basin are four three-stage, Morris motor-driven, centrifugal pumps, three of which are rated at a capacity of 700 gal. per min. driven by 75-hp. Wagner motors, and one at 400 gal., the motor rating being 40 hp. These deliver the water to the reservoir on the tower and the piping system at a head of 230 ft. Eddy check and gate valves are used in the pumping plant.

Three 3-phase transformers of 75 kv.a. capacity; one 3-phase of 37.5 kv.a.; and one single-phase, 5 kv.a. step the voltage of the distribution line down to 220 v. for the motors and 110 v. for the lights. Hand operated Cutler-Hammer starting controls are used for all the pump motors except that for the sump which is a Wagner motor with a Sundh automatic control.

Boiler Water---I

A Study of the Chemistry and Treatment of Water Used for Feeding Purposes. By C. E. Joos and A. W. Binns

NEARLY ALL natural waters contain impurities in the form of salts, usually salts of calcium and magnesium; these impurities are the incrusting solids found in boiler scale and deposits; a water containing these incrusting solids is said to be hard. It is the purpose of the treating plant to take out these solids and make the water soft and fit for boiler feed purposes.

Temporary Hardness

By temporary hardness we mean those dissolved salts in the form of bi-carbonates. These bi-carbonates are formed by the action of the carbonic acid (carbon dioxide plus water) on rocks such as limestone, etc. The reaction may be represented thus:

$$\underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Limestone}}{CaCO_3} = \underset{\substack{\text{Calcium}\\\text{Bi-carbonate}}}{Ca(HCO_3)_2}$$

This same reaction applies to the carbonate of magnesia. When these bi-carbonates are heated they lose their CO_2 and the limestone or calcium carbonate is precipitated. In the water treating plant, these salts are precipitated by means of caustic soda, lime or both. The reactions are as follows:

$$\underset{\substack{\text{Calcium}\\\text{bi-carbonate}}}{Ca(HCO_3)_2} + \underset{\substack{\text{Caustic}\\\text{Soda}}}{2NaOH} = \underset{\substack{\text{Calcium}\\\text{Carbonate}}}{CaCO_3} + \underset{\text{Soda Ash}}{Na_2Co_3} + \underset{\text{Water}}{2H_2O}$$

$$\underset{\substack{\text{Magnesium}\\\text{Bicarbonate}}}{Mg(HCO_3)_2} + 4NaOH = \underset{\substack{\text{Magnesium}\\\text{Hydroxide}}}{Mg(OH)_2} + 2Na_2CO_3 + 2H_2O$$

$$\underset{\substack{\text{Calcium}\\\text{Bi-carbonate}}}{Ca(HCO_3)_2} + \underset{\substack{\text{Lime}\\\text{(Slacked)}}}{Ca(OH)_2} = 2CaCO_3 + 2H_2O$$

It will be noticed that in each of these cases where (NaOH) caustic soda is used, sodium carbonate or soda ash (Na_2CO_3) is a by-product in the reaction; when lime is used no such alkaline by-product is formed.

Permanent Hardness

The permanent hardness is made up principally of the normal salts of calcium and magnesium, the salts of aluminum and iron are also classed here. These salts

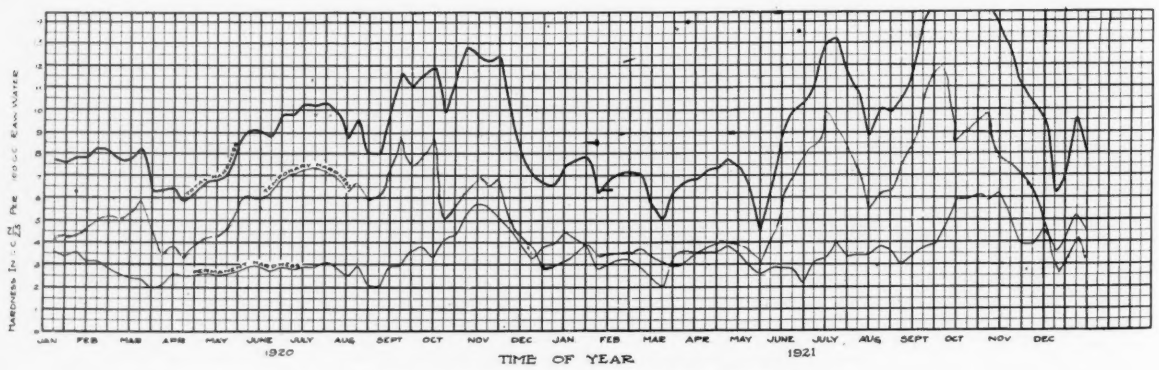


FIG. 1. HARDNESS CURVES OF SCHUYLKILL RIVER WATER

are precipitated in the treating plant by means of soda ash or sodium carbonate. The reactions are as follows:

$$\underset{\text{Calcium Sulphate}}{CaSO_4} + \underset{\text{Soda Ash}}{Na_2CO_3} = CaCO_3 + Na_2SO_4$$

$$\underset{\substack{\text{Magnesium}\\\text{Sulphate}}}{MgSO_4} + \underset{\text{Soda Ash}}{Na_2CO_3} = MgCO_3 + Na_2SO_4$$

The magnesium sulphate, $MgSO_4$, may also be precipitated by caustic soda thus:

$$MgSO_4 + 2NaOH = Mg(OH)_2 + Na_2SO_4$$

Indicators

Phenolphthalein and methyl orange are the two common indicators used in water analysis and because of their different actions towards different alkalis they are ideal for this purpose. Alkalis such as hydroxides, carbonates and bicarbonates react alkaline with methyl orange and the total amount present may be determined by using methyl-orange alone. Phenolphthalein on the

other hand indicates all hydroxides but only one-half the amount of normal carbonates and none of the bicarbonates. The following conditions are possible:

I. If the alkalinity determined by the use of phenolphthalein (P) should be zero then the alkalinity shown by the methyl-orange (M) would be due to bicarbonates alone. Example: 0.0 — 3.0

Such a titration indicates all bicarbonates as $NaHCO_3$ or $Ca(HCO_3)_2$ sodium and calcium bicarbonate respectively.

II. If the alkalinity (P) shown by phenolphthalein should be half the total alkalinity as shown by methyl-orange (M) then the alkalinity would be due to normal carbonates alone. Example: 1.5 — 3.0.

This titration would indicate normal carbonates as Na_2CO_3, soda ash.

III. If (P) should be less than one-half (M) then the titration would indicate a mixture of bicarbonates and normal carbonates, and they could be calculated as follows:

Carbonates 2P
Bicarbonates M — 2P
Example: 1.5 — 4.0
Carbonates $1.5 \times 2 = 3.0$
Bicarbonates $4.0 - 3.0 = 1.0$

IV. If (P) should be greater than one-half (M) then the alkalinity would be due to a mixture of hydroxide and normal carbonate and the quantities would be calculated as follows:

Hydroxide 2P — M
Carbonate (M — P)2
Example: 2.0 — 3.0
Hydroxides $2 \times 2 - 3 = 1$
Carbonates $(3 - 2)2 = 2$

When a water is titrated for alkalinity, the phenolphthalein is added first (two drops) and then the water is titrated with standard acid until the red color disappears. This is the first reading (P). Two drops of the methyl-orange are added and titrated until the color changes to a pink.

Phenolphthalein is colorless in acid solution and pink in alkaline solution. Methyl-orange is orange in alkaline solution and pink or red in acid solution.

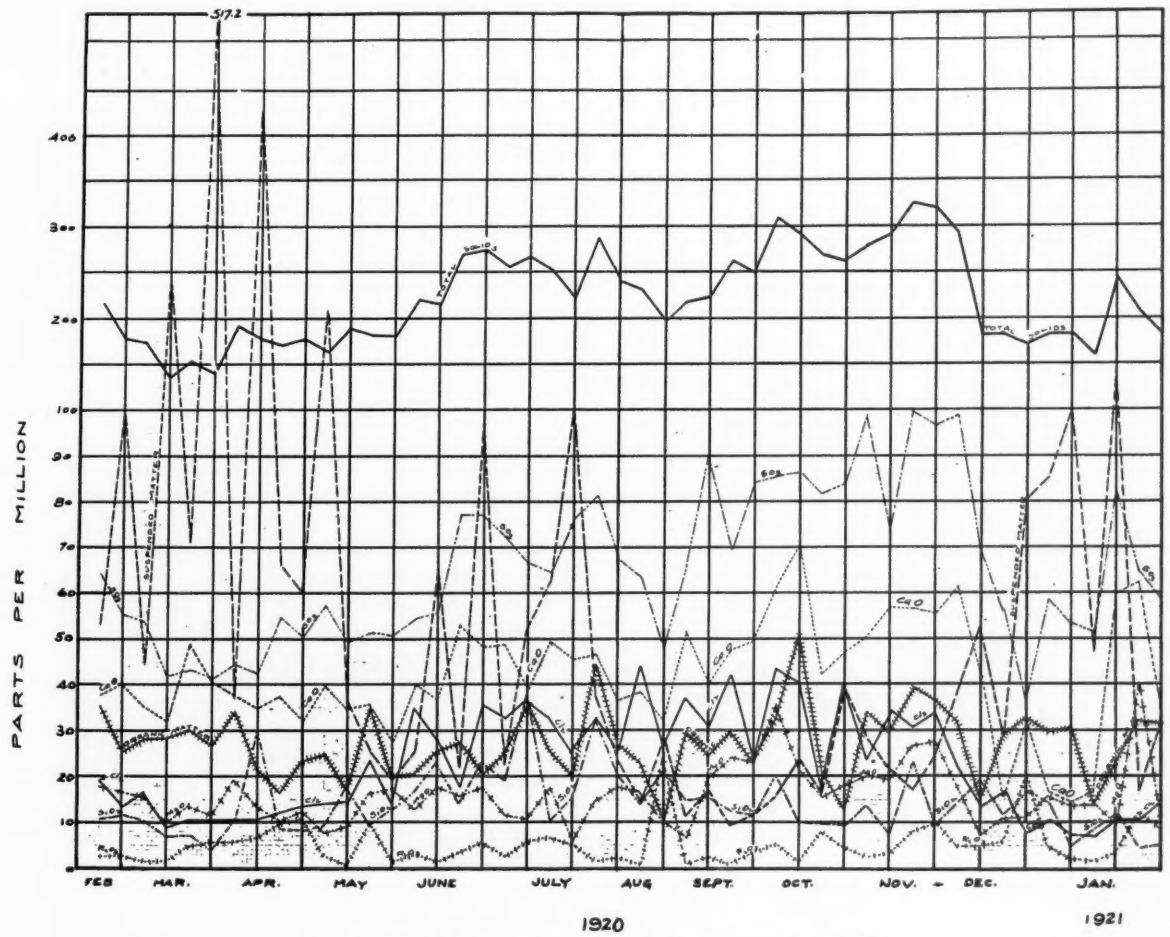


FIG. 2. ANALYSIS OF SCHUYLKILL RIVER WATER DURING 1920

Normal Solutions

THE METHOD of making up normal solutions can be gotten from any textbook on quantitative analysis. It will suffice for us to say that a given quantity of normal acid will neutralize the same quantity of normal alkali. Thus a c.c. of normal hydrochloric acid will exactly neu-

tralize a c.c. of normal caustic soda or any other alkali. This is the basis on which our determinations are made.

Titration

Titration in water treating simply means the neutralization of alkali by standard acid. By knowing the amount of acid used and its strength we can easily calculate the strength of the alkali in question.

Method of Analysis

In this method 500 c.c. of raw water is placed in a 750 c.c. Erlenmeyer flask and 50 c.c. of 1/5 normal sodium carbonate is added and the whole allowed to stand for 5 min. It is then heated to 200 to 210 deg. F. in a water bath for 10 min. and cooled to room temperature. This is filtered, discarding the first 100 c.c. because of the absorption of the alkali by the filter paper; 110 c.c. is then titrated. This represents 1/5 of the total, or 100 c.c. raw water and 10 c.c. N/5 sodium

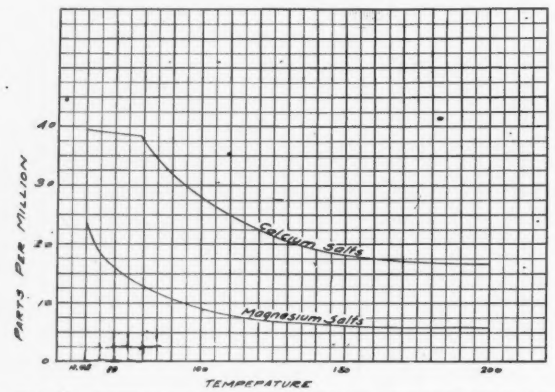


FIG. 3. EFFECT OF TEMPERATURE ON PRECIPITATION OF SCALE-FORMING SALTS IN RAW WATER

carbonate. If 1/25 normal hydrochloric acid is used in the titration, the reading is something like this:

	Phenolphthalein	Methyl-orange
c.c. N/25 — HCl	20.0	47.0

The chemical reactions involved in this process are as indicated below. In the case of temporary hardness, the sodium of the sodium carbonate exchanges with the calcium or magnesium in the calcium or magnesium bicarbonates.

$$Ca(HCO_3)_2 + Na_2CO_3 = 2NaHCO_3 + CaCO_3$$
$$Mg(HCO_3)_2 + Na_2CO_3 = 2NaHCO_3 + MgCO_3$$

The $CaCO_3$, calcium carbonate, is insoluble and is precipitated; the $NaHCO_3$, sodium bicarbonate is soluble and may be calculated. It will be noticed that the bicarbonate radical (HCO_3) remains unchanged and its determination is an indication of the amount of temporary hardness present. Therefore, to determine the temporary hardness we merely calculate the amount of bicarbonates present. The permanent hardness, or the normal salts of calcium and magnesium, are precipitated by sodium carbonate as normal carbonates. The reactions are as follows:

$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$
$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

In these reactions the sodium carbonate is consumed without giving any alkaline byproduct as in the case of temporary hardness. The sodium sulphate Na_2SO_4 is a neutral salt. Therefore, to calculate the permanent hardness it is only necessary to calculate the amount of Na_2CO_3 consumed to precipitate the $CaSO_4$ and $MgSO_4$.

Temporary Hardness

Above we showed how the determination of the bicarbonate was a measure of the temporary hardness in the water. Under the head of indicators, we learned that the phenolphthalein was not alkaline to bicarbonates and in order to calculate the amount present we used the following formulas:

Carbonates 2P — Bicarbonates M-2P

Taking the titration

Phenolphthalein	Methyl-orange
40.0	47.0

The amount of temporary hardness or bicarbonates would be

$$47.0 - 40 = 7.0$$

This means that for every 100 c.c. of raw water there is temporary hardness present to the extent of 7.0 c.c. in terms of N/25 solution. We now know the exact amount and strength of our temporary hardness and it is easy to calculate the amount of precipitating agents used in the treating plant. From the molecular weights of the substances we find that 74 lb. of lime in the form of $Ca(OH)_2$ or 56 lb. in the form of CaO, will precipitate 162 lb. of temporary hardness in the form of $Ca(HCO_3)_2$; if the precipitating agent is caustic soda, the amount necessary would be 80 lb. Now in speaking in terms of normal solutions, we know that 1 c.c. of normal NaOH will exactly precipitate 1 c.c. of temporary hardness expressed in terms of normal solutions whether the hardness is in the form of calcium or magnesium bicarbonate. Thus in the case mentioned above, it would take 7.0 c.c. N/25 caustic soda or lime to precipitate the hardness in 100 c.c. of water. The amounts of chemicals per 10,000 gal. is merely a matter of calculation and is given in a table.

Permanent Hardness

It was mentioned above, in the precipitation of the permanent hardness, the Na_2CO_3 that was used in the reaction was entirely consumed and produced a neutral salt as a byproduct. Now if we know the original value of the total alkali in the solution, and the value after precipitation, the difference would then be the permanent hardness. In our original solution, we added 50 c.c. N/5 Na_2CO_3 for every 500 c.c. of raw water. Therefore the 110 c.c. we titrate represents 100 c.c. raw water and 10 c.c. N/5 Na_2CO_3. Now if we titrate 10 c.c. of N/5 Na_2CO_3 with N/25 hydrochloric acid, the reading would be:

P, 25.0; M, 50.0.

Thus 50 would represent the total content of carbonate that we use with every 100 c.c. of raw water in our analysis. Since, after precipitation, we got a value of 47.0, the difference 50.0 — 47.0, or 3, would represent the amount of permanent hardness present in the terms of c.c. of N/25 solution per 100 c.c. water. Since we know that 3 c.c. of N/25 Na_2CO_3 will exactly precipitate our permanent hardness in 100 c.c. of raw water, it is easy to calculate the amount of soda ash necessary for any quantity of raw water.

In the operation of the treating plant, if the temporary hardness is greater than the permanent, we

use both caustic soda and lime as our precipitating agents. Referring to our reactions of temporary hardness with caustic soda, it should be noticed that sodium carbonate Na_2CO_3 is a byproduct thus: $Ca(HCO)_3 + 2NaOH = CaCO_3 + Na_2CO_3$ and in terms of normal solutions the Na_2CO_3 produced is exactly the same strength as the caustic soda originally used. With this in mind in our original case, we have a temporary hardness of 7.0 and a permanent hardness of 3.0, then there will be produced from this reaction 3.0 of Na_2CO_3, an amount sufficient to precipitate the permanent hardness. Now we still have 4.0 equivalents of temporary hardness to remove, and we add lime to this amount since it does not produce an alkaline byproduct. Thus in calculating a treatment, the procedure is as follows:

Temporary 7.0
Permanent 4.0 (Caustic Soda)

3.0 (Lime)

The pounds per 10,000 gal. is gotten by calculation or reference to table.

When to Use Soda Ash and Caustic Soda

In the foregoing we have assumed that the temporary hardness was always greater than the permanent. This, however, is only one case. The permanent hardness may be equal to or greater than the temporary hardness. The following rules are good ones to follow:

Let T be temporary hardness
P be permanent hardness

Then if T is greater than P the treatment will be caustic and lime. The caustic will be added to the amount of T — P.

If T is equal to P, then the treatment will be caustic only, to the amount of T or P.

If P is greater than T, the treatment will be caustic soda and soda ash. The caustic soda will be introduced to the amount of T and the soda ash to the amount of P — T. The reasons for the above treatments all depend upon the following reaction:

$$Ca(HCO_3)_2 + 2NaOH = Na_2CO_3 + CaCO_3 + 2H_2O$$
$$Mg(HCO_3)_2 + 4NaOH = 2Na_2CO_3 + 2H_2O$$

In the first case, let us assume that the temporary hardness is 7 and the permanent hardness is 3. Now if we add caustic to the amount of 3 we produce by the above reaction the value of 3 in soda ash and precipitate 3 of temporary hardness. This is just enough Na_2CO_3 to precipitate our permanent hardness. Now we have precipitated all our permanent hardness and our temporary hardness by the amount of 3 and we still have left 4 of temporary hardness and this is precipitated by lime. In treating 10,000 gal. of raw water, the procedure would be as follows:

T 7
P 4 (Caustic)

3 (Lime)

Referring to the tables we add 20.4 lb. of caustic soda and 2.802 lb. of lime (100 per cent).

In the second case, let us assume that T = P and each is four (4). Now if we add 4 of caustic we precipitate 4 of temporary hardness and produce an equal amount of soda ash, which is just sufficient to precipitate the permanent hardness. The 10,000 gal. would be treated as follows:

T 4
P 4 (Caustic)

T — P 0

This represents 20.4 lb. of caustic.

Caustic Soda Conversion Table 34 deg. Bé

c.c. N/25 Hardness	NaOH 10,000 gal.	c.c. N/25 Hardness	NaOH 10,000 gal.	c.c. N/25 Hardness	NaOH 10,000 gal.
1.0	5.1	2.4	12.2	3.8	19.4
1.1	5.6	2.5	12.8	3.9	19.9
1.2	6.1	2.6	13.3	4.0	20.4
1.3	6.6	2.7	13.8	4.1	20.9
1.4	7.1	2.8	14.3	4.2	21.4
1.5	7.7	2.9	14.8	4.3	21.9
1.6	8.2	3.0	15.3	4.4	22.4
1.7	8.7	3.1	15.8	4.5	23.0
1.8	9.2	3.2	16.3	4.6	23.5
1.9	9.7	3.3	16.8	4.7	24.0
2.0	10.2	3.4	17.3	4.8	24.5
2.1	10.7	3.5	17.9	4.9	25.0
2.2	11.2	3.6	18.4	5.0	25.5
2.3	11.7	3.7	18.9		

Soda Ash Conversion Table 95 Per Cent

c.c. N/25 Hardness	Na_2CO_3 10,000 gal.	c.c. N/25 Hardness	Na_2CO_3 10,000 gal.	c.c. N/25 Hardness	Na_2CO_3 10,000 gal.
0.1	0.186	1.6	2.98	3.1	5.77
0.2	0.372	1.7	3.16	3.2	5.95
0.3	0.558	1.8	3.35	3.3	6.14
0.4	0.744	1.9	3.53	3.4	6.32
0.5	0.930	2.0	3.72	3.5	6.51
0.6	1.116	2.1	3.91	3.6	6.70
0.7	1.302	2.2	4.09	3.7	6.88
0.8	1.488	2.3	4.28	3.8	7.07
0.9	1.674	2.4	4.46	3.9	7.25
1.0	1.86	2.5	4.65	4.0	7.44
1.1	2.05	2.6	4.84	4.1	7.63
1.2	2.23	2.7	5.02	4.2	7.81
1.3	2.42	2.8	5.21	4.3	8.00
1.4	2.60	2.9	5.39	4.4	8.18
1.5	2.79	3.0	5.58	4.5	8.37

Lime Conversion Table 100 Per Cent CaO

c.c. N/25 Hardness	CaO 10,00 gal.	c.c. N/25 Hardness	CaO 10,000 gal.
0.1	0.093	1.9	1.775
0.2	0.187	2.0	1.868
0.3	0.280	2.1	1.961
0.4	0.374	2.2	2.055
0.5	0.467	2.3	2.148
0.6	0.560	2.4	2.242
0.7	0.654	2.5	2.335
0.8	0.747	2.6	2.428
0.9	0.841	2.7	2.522
1.0	0.934	2.8	2.615
1.1	1.027	2.9	2.709
1.2	1.121	3.0	2.80
1.3	1.214	3.1	2.89
1.4	1.308	3.2	2.98
1.5	1.401	3.3	3.08
1.6	1.494	3.4	3.17
1.7	1.588	3.5	
1.8	1.681		

In the third case, let us assume temporary hardness (T) to be 3 and permanent hardness P to be 5. Applying the above rule, we have

P 5
T 3 (Caustic)

P — T 2 (Soda Ash)

In this case when we add 3 of caustic, we precipitate all our temporary hardness and produce 3 of soda ash which will precipitate 3 of our permanent hardness. Now we still have 2 of our permanent hardness to be precipitated and this is done by adding 2 of soda ash. In all of the preceding it must be remembered that we are speaking in terms of normal solutions.

Water Control

From Fig. 1. it is evident that the raw water is subject to rapid changes due to rain, thaws and the like. For this reason it is advisable to make an analysis of the raw water daily; however, the major part of the control should be based on the titration of the treated water.

Treated Water Tests

If the intermittent system is used, each tank should be sampled and the water tested as follows: 100 c.c. is heated to boiling, cooled, and then titrated with N/25 hydrochloric acid, using phenolphthalein and methyl-orange as indicators. Under ordinary conditions, this reading should be about 1.8 for the phenolphthalein reading and 3.0 for the methyl-orange reading. This represents 20 per cent hydrates and 80 per cent carbonates. From experience this condition seems to be ideal. If the reading shows the presence of bicarbonates and sufficient carbonates then we know more lime should be added. The amount is determined from the raw water analysis or by experience in knowing the effect of the addition of a certain amount of lime or caustic. If the readings are higher than the ideal case, we know that too much chemical has been used and changes can be made accordingly.

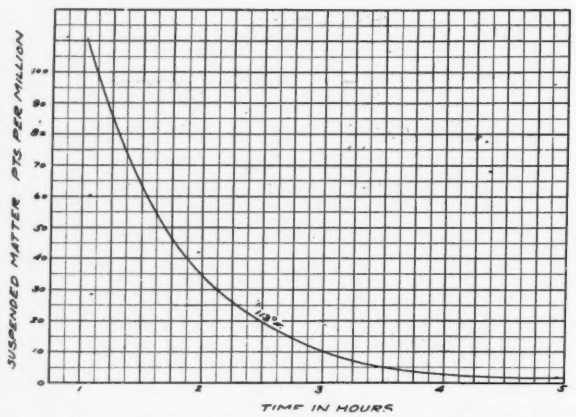


Fig. 4. Relation of Suspended Matter to Time of Settling

Precipitation Tests

This test is interesting inasmuch as it is indicative of the efficiency of the chemical treatment and is performed as follows:

One hundred c.c. of treated water with the addition of 10 c.c. of N/25 Na_2CO_3 is heated to 200 to 210 deg. F., cooled and poured into a 100-c.c. precipitating tube and allowed to stand over night. The amount of precipitate collected is inversely proportional to the efficiency of the plant. This test, coupled with the treated water test mentioned above, form excellent methods of control.

Boiler Water Test

This is merely a determination of the alkali in the boiler water and is carried out by titrating 100 c.c. with N/25 hydrochloric acid. The ideal case is to have an alkalinity of about 30.

(To be continued)

Hydroelectric Developments in Australia

While most of Australia is a riverless, lakeless country, there are parts of Tasmania, northern Victoria, eastern New South Wales and northern Queensland which have mountains and between them narrow valleys with swift, steadily flowing rivers which are capable of improvement for power and for which plans are under way. At Tasmanian Great Lake the Government took over a partial development in 1914 and by 1917 was able to supply to a zinc company 30,000 hp. at about $9.60 a year. The plant of the zinc company is located at Hobart, the power being transmitted at high voltage for it and also for a carbide works and the lighting and street cars of the city.

The lake is on a plateau about 62 mi. from Hobart and had naturally the flow of the Shannon River. A canal was built to divert the waters of the Ouse River also into the lake in 1921 and at the same time a dam was built which raised the level of the lake 29 ft. above the former, or 40 ft. in all. The Shannon at the outlet is carried through high banks 12 mi. to a pool and there drops 1100 ft. through iron flumes to the power house, where 36,000 hp. of water wheels and generators are installed. The plant capacity is to be doubled within a year. Of this, 52,000 hp. will be sent to Hobart, and 10,000 hp. to Launceston on the other side of the island. By connecting Lake Arthur to Great Lake, it is estimated that the power can be increased to 85,000 and later to 100,000 by extension of the drainage basin which feeds the lake.

There is also an independent hydroelectric plant of the Mount Lyell Railway & Mining Co. on the west coast of 10,000 hp. and other regions have been surveyed so that the estimated power on the island is put at 200,000.

Exports of American industrial machinery show an increase of something like 170 per cent in value in 1921 over 1913, according to the Industrial Machinery Division of the Department of Commerce in a special review of the machinery export situation in which statistics for the first 11 mo. of 1921 are used to estimate the year's trade. Exports of industrial machinery for the first 11 mo. of 1921 were valued at $238,007,585 against $92,312,457 for all of 1913. While official figures for the calendar year 1921 are not yet available, $250,000,000 is, in the opinion of the Division, a conservative estimate of the total value of the trade during the year which has just closed.

Season Cracking in Condenser Tubes

THE REMOVAL OF INTERNAL STRESS IN CONDENSER TUBES FOR THE PREVENTION OF SEASON CRACKING

THE SPLITTING of condenser tubes while in service does not occur as frequently as some other types of tube failures, but is nevertheless a serious matter, and of late has received considerable attention. Tube failures of this type are often spoken of as age, or season, cracking and are quite similar, at least in the results produced, to seam cracks in welded tubes.

Investigations seem to indicate that season cracking is due partly to internal stresses in the metal of the tubes which in turn is influenced by the heat treatment which the tube receives in process of manufacture. The removal of such internal stresses would therefore bring about a reduction in the number of season cracks.

H. Moore and S. Beckinsale, in England, have investigated the problem quite thoroughly, and in a discussion of a paper on the subject which they presented to the Institute of Metals, some two years ago, the president suggested that the method of low temperature annealing recommended for the removal of internal stress in brass, be applied to Admiralty condenser tubes.

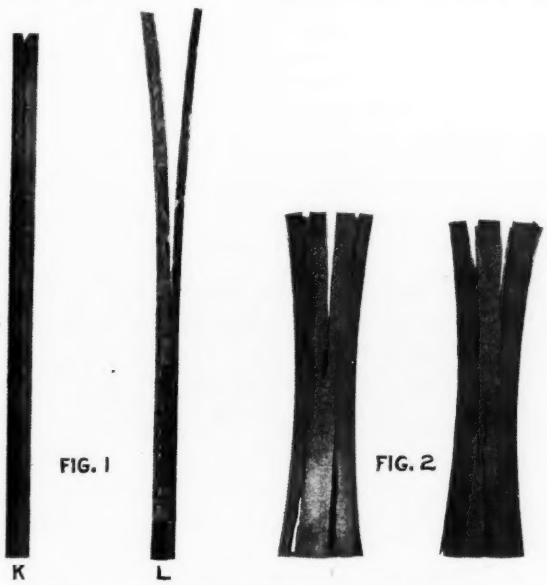


FIG. 1. SPLIT CONDENSER TUBES AS RECEIVED

FIG. 2. CONDENSER TUBES IN A STATE OF HIGH INTERNAL STRESS, SHOWN AFTER TREATMENT IN MERCUROUS NITRATE SOLUTION

As a consequence of this suggestion an investigation was undertaken and the results were read before the Institute of Metals on March 9 of this year and subsequently published in Engineering, of London.

The work involved in this investigation consisted of:

1. The examination of two split condenser tubes.
2. The determination of the properties of condenser tubes made by different manufacturers.
3. Experiments on condenser tubes purposely made by methods leaving high internal stress.
4. An investigation of the rate of reduction of stress in condenser tube brass during low-temperature annealing.
5. The determination of the effect of heat treatment in the range 200 deg. to 325 deg. C. on the properties of brass of condenser tube composition.

The material used was either actual Admiralty condenser tubes (external diameter 5/8 in.; thickness of wall, 0.048 in.), or brass of Admiralty condenser tube composition (70:29:1).

The condenser tubes examined are those shown in Fig. 1. The tube K had cracked in store, while L had cracked in service. Tube K had an irregular longitudinal crack 0.05 in. wide at its widest part. Tube L, when it was received, had been cut longitudinally by a diametral cut about 90 deg. from the crack. The springing apart of the two halves shown in Fig. 1 indicated that longitudinal stress as well as circumferential stress had been present.

A piece of corroded tube cut from each sample was immersed in 5 c.c. of distilled water for one day. One c.c. of Nessler's solution was then added to each vessel. The water extract from K became brown, indicating the presence of ammonia, while that from L and a sample of distilled water submitted to the same conditions and test as a control remained clear and colorless. Repetition of this test always gave the same results.

PROPERTIES OF ADMIRALTY CONDENSER TUBES

TWO SETS OF samples were selected at random from eight different makers at an interval of some months. Short lengths of each sample tube were immersed for five minutes in a 1 per cent mercurous nitrate solution after pickling in nitric acid. All were free from cracks on removal from the station. One sample developed fine longitudinal cracks within 24 hr. None of the other pieces cracked during 56 days' storage in a closed space after the mercurous nitrate treatment. Short lengths were exposed over an ammonia solution in a closed space. Cracks developed in two makes. Pieces of one of these two makes were then annealed at 275 deg. C. for 1 hr. and submitted to the mercurous nitrate test. No cracks developed.

CONDENSER TUBES IN A HIGH STATE OF INTERNAL STRESS

FOR THIS part of the investigation a certain firm in England was asked to supply a quantity of condenser tubing in which high internal stresses were purposely induced. The tubes were otherwise to comply with the Admiralty specification. It was agreed that the tubes should satisfy the requirement that they should develop open cracks within 20 min. of application of the mercurous nitrate test.

A number of pieces of this tubing were submitted to the mercurous nitrate test and each cracked within 40 seconds of immersion. The cracks gradually developed until they assumed the form shown in Fig. 2; microscopic examination showed that they followed the boundaries of the crystals.

Three-inch lengths cut from the tubes were heated in a salt bath at various temperatures and for varying periods of time. Four pieces were subjected to each treatment, and the Brinell hardness was then determined

on two and the mercurous nitrate test was applied to the other two. In the untreated state, this lot of tubing was found to be unusually susceptible to the development of cracks of the character of season cracks. This is regarded as an indication of the presence of exceptionally high stress, which might also be inferred from the form assumed after cracking (Fig. 2) and from the gaping of longitudinal cuts made in short lengths.

The tubes were highly susceptible also to the action of ammonia present in small concentration. Cracks have not developed, however, in conditions in which the presence of traces of mercury or ammonia could not be established.

It has been widely believed that season cracking may be brought about in brass by the action of stress alone, if the stress is sufficiently high and prolonged. This view is not supported by the experience of the authors, who have suggested elsewhere that for the development of season cracks in brass at atmospheric or lower tem-

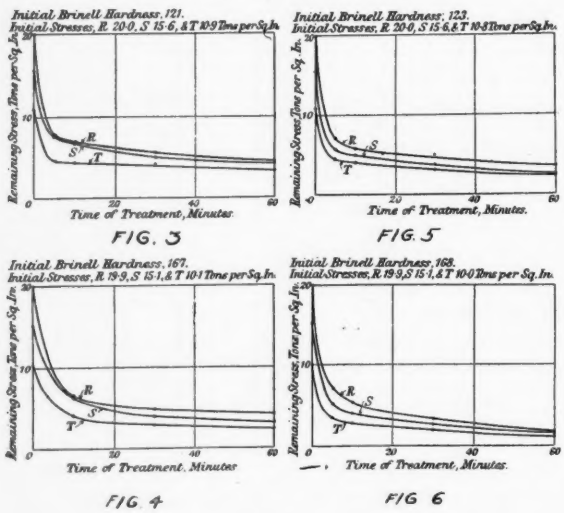

Initial Brinell Hardness, 121.
Initial Stresses; R. 20·0, S 15·6, & T 10·9 Tons per Sq. In.
Initial Brinell Hardness, 123.
Initial Stresses; R. 20·0, S 15·6, & T 10·8 Tons per Sq. In.
Remaining Stress, Tons per Sq. In.
Time of Treatment, Minutes.
FIG. 3
FIG. 5
Initial Brinell Hardness, 167.
Initial Stresses; R. 19·9, S 15·1, & T 10·1 Tons per Sq. In.
Initial Brinell Hardness, 168.
Initial Stresses; R. 19·9, S 15·1, & T 10·0 Tons per Sq. In.
FIG. 4
FIG. 6

FIG. 3 AND FIG. 4. REDUCTION OF STRESS IN STRIPS OF ADMIRALTY CONDENSER TUBE METAL BY TREATMENT AT 275 DEG. C.

FIG. 5 AND FIG. 6. REDUCTION OF STRESS IN STRIPS OF ADMIRALTY CONDENSER TUBE METAL BY TREATMENT AT 300 DEG. C.

peratures some chemical or similar action on the surface is necessary in addition to the presence of stress. The behavior of this lot of highly-stressed condenser tube during the months in which it has been under observation and used in experiments has so far supported the views of the authors.

The Removal of Stress

In the highly-stressed tubes used, treatment at 275 deg. C. for 2 hr. or at 300 deg. C. for one hour, reduces the stress below the limit at which cracks can be produced by the action of mercury and has very little effect on the hardness of the tubes. A series of similar treatments of spun cups made from sheets of Admiralty condenser tube composition showed that the liability to crack under the action of mercury was removed by a treatment at 275 deg. C. for 1 hour.

In addition to the foregoing, a number of experiments were carried out with the view of obtaining quantitative information on the reduction of initial stress brought about by low-temperature annealing under different conditions of (1) initial hardness, (2) initial stress, (3) time, and (4) temperature of annealing. A typical series of results of this experiment are shown graphically in Figs. 3 to 6.

General Conclusions

While only two specimens of cracked tubes were examined in these investigations, many others have been examined elsewhere, and there is no reason to doubt that the splitting of condenser tubes is an example of the season cracking of brass. The cracks commonly follow an intercrystalline path, and the springing apart occurring on the formation of a crack indicates the relief of initial stress. The tube (k) which had cracked in store resembled other specimens of season-cracked brass investigated by the authors in having ammonium compounds present in the corrosion product coating the fractures. The freedom of the corrosion product of the other tube from ammonium compounds may be due to their removal by water while the tube was in service.

The presence in the condenser cooling water of ammonium compounds due to sewage contamination is dangerous when the tubes are in a state of internal stress, owing to the powerful effect of ammonia and its compounds in inducing the cracking of stressed brass. This emphasizes the wisdom of ensuring that condenser tubes are not taken into service in a state of high stress.

The experimental work reported in the present paper has been mainly directed to the subject of the reduction of internal stress by low-temperature annealing. The results of these experiments may be summarized in the following conclusions:

1. The rate of reduction of stress at the lower temperatures is fairly rapid during the first part of the heat treatment, but becomes slow when the stress has been considerably reduced.

2. As the temperature is raised the rate of reduction of stress increases, but shows the characteristic of slowing down as the stress falls during the treatment.

3. The higher the initial stress, the higher is the remaining stress after a given treatment in condenser tube brass of the same hardness, although the amount of stress removed is greater the higher the initial stress.

4. The higher the hardness of the brass, the lower is the remaining stress after a given treatment and for a given initial stress.

In order to reduce the stress below the limit at which mercury treatment causes cracking in the experimental tubes in which high initial stress had been purposely developed, treatment at 275 deg. C. for 2 hr., or at 300 deg. C. for 1 hr., was found necessary. There is no doubt that in these tubes the initial tension at the surface was extremely high. It is most improbable that such highly stressed tubes would ever be supplied for use, and although treatment at 275 deg. C. for 2 hr. may be applied without appreciable loss of strength, a shorter treatment at this temperature would be sufficient to reduce stress to a safe limit in condenser tubes as manufactured.

Abating a Smoke Nuisance

USE OF WATER-GRATES INCREASES CIRCULATION OF BOILER WATER, REDUCES ATTENTION REQUIRED AND ELIMINATES SMOKE. BY R. R. HILLMAN

PROBABLY there are few engineers who have not had a fair share of nostrums or wonderful cure-alls offered them to correct the troubles of the power house and boiler room. Possibly at the head of these stand the various contrivances called "smoke-consumers." With the stiffening of the ordinances against smoke nuisance in our larger cities, scheme after scheme is put forward to consume the obnoxious element, no attention being paid to the fact that the only way to avoid smoke in objectionable quantities is—not to make it in the first place.

An old established department store in Buffalo, N. Y., had attained, a year or two since, an undesired prominence in the eye of the local smoke inspector. Several neighbors were almost equally favored. The frequent visits of this official were becoming anything but welcome, although personally he was an agreeable young man. He pleasantly, but firmly, insisted that something must be done to moderate the rolling black clouds that issued from the chimney practically all day. The managers would have been only too glad to comply. A sooty office and ruined dry-goods are not indispensable blessings.

At about this time the writer, who is consulting engineer for the firm, was urged to make a trial of the furnace which is the subject of this article. When it was suggested, he recalled having inspected a similar

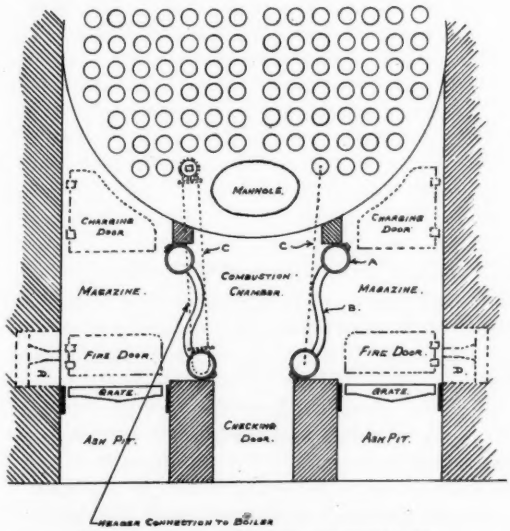


FIG. 1. CROSS SECTION OF FURNACE

installation 5 or 6 yr. before in the boiler house of a large institution in South Buffalo, where the combustion results were excellent, but the construction of the apparatus not at all a satisfactory mechanical job. The principle of the contrivance seemed to be correct as far as combustion is concerned, even though the mechanical details were not by any means well worked out. The situation was urgent, and it was finally agreed to make a trial of the furnace, provided certain specifications were observed in the construction. A carefully drawn-up agreement was signed whereby the department store agreed to make a trial of the furnace during one winter's run under one of its boilers, and if found satisfactory it would be accepted and paid for; if not, it was to be removed, and the original furnace restored. Detailed plans were also to be furnished for approval. The two points of insistence were, as far as operation was concerned, that it should eliminate the smoke nuisance and that it should not consume any more fuel than the old furnace, per day.

DESCRIPTION OF THE FURNACE

THE INSTALLATION was very simple. A new front was, of course, necessary. Instead of the ordinary horizontal grate under the boiler, there were provided two vertical sets of water-grates, consisting of 19 S-tubes of 1½-in. pipe (B), rolled into top and bottom headers

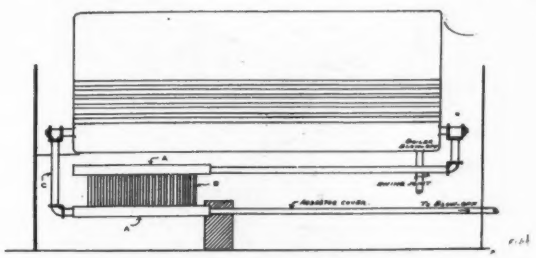


FIG. 2. SIDE ELEVATION OF FURNACE SHOWING CONNECTION OF WATER-GRATES TO BOILER

made of 5-in. steel pipe (A). These grates are plainly shown in position in Fig. 1. In previous installations these water-grates had been poorly constructed, and gave trouble by leaking. It will be noticed that there is a screw plug opposite each tube in each header. This enabled the tubes to be thoroughly rolled into the headers and a hydrostatic pressure of 600 lb. per square inch on the completed frame failed to start a leak.

Two fire-tubes, one on each side of the manhole of the boiler, were removed. The front ends of the lower headers were connected with the boiler through the two forward holes thus made, while the two back ends of the upper headers were connected by long pipes to the boiler through the two rear holes. The other two ends of the upper headers were capped. The other two ends of the lower headers were led to two blowoff valves outside of the setting, which were independent of the regular boiler blowoff. These connections are shown in the side elevation, Fig. 2. The space between the upper headers and the boiler shell was bricked up, while special brick tile, perforated for draft, formed the side of the magazine opposite the water-grates.

The regular shaking grate of the Cyclone Grate Bar Co., of Buffalo, was introduced at the bottom of the magazine. It will be seen at once that the space between the water bars or grates forms a long combustion chamber under the boiler. The back walls of the magazines and the bridgewall form an opening through which the burning gases pass and spread themselves beneath the

rear half of the boiler. A peep-hole is provided in the front to allow inspection of this chamber. The whole contrivance is so simple that the accompanying figures make its construction very clear. The boiler is of the ordinary return tubular type, 6 ft. in diameter by 16 ft. long. It has 86 fire-tubes (84 under the present scheme) and is rated at 125 hp. The working pressure is supposed to be 125 lb., but the pops are set at a trifle over 100 lb.

Operation of the Furnace

One of the principal obstacles against which this new outfit had to struggle is poor draft. The chimney of this plant, although recently built, has never been adequate in height, which was one of the factors in the production of heavy smoke. There are a number of reasons why it is not practicable at present to add materially to the height of the stack. It was found necessary to run at all times with the damper wide open,

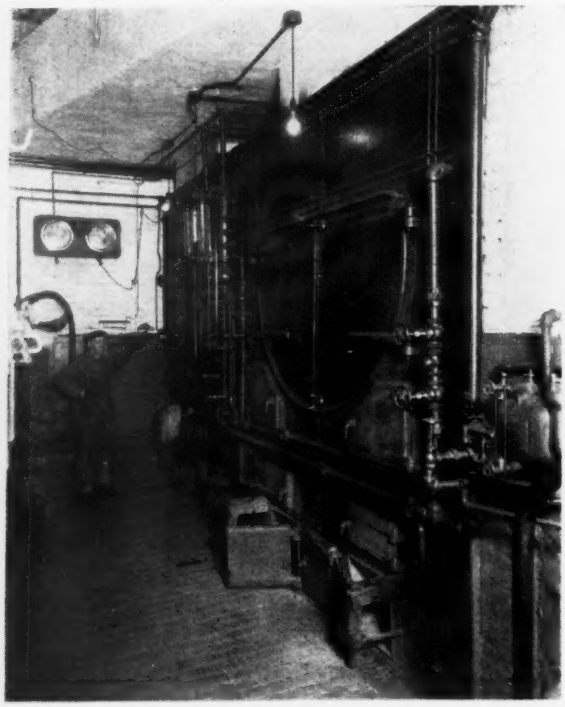


FIG. 3. FRONT OF BOILERS EQUIPPED WITH WATER-GRATE FURNACES

and the gage shows a general draft of 0.2 in., only reaching from 0.25 to 0.3 in. under the most favorable snappy weather conditions. Without doubt, under the influence of a proper draft, better results would have been attained even than those which follow.

After a month or six weeks, the smoke inspector ceased to call. Frequent observations during the winter's run failed to show a smoke density greater than No. 2 of the Ringlemann scale, that is, dark, 40 per cent black, and that amount only for 2 or 3 min. when the fire was being sliced. During far the greater portion of the time only a thin white smoke film issues from the chimney. This is a logical sequence of the method of firing. The magazines being full of coal, and an incandescent bed lying on the grate at the bottom of the mass, the gases are distilled rapidly from the coal above, and burn through the water-grates and back through the combustion chamber. The action is somewhat similar in principle to that of the mechanical stoker in this respect. In the present case, there is not a heavy demand for steam—only a steady one—so that the fire is seldom sliced. Undoubtedly the smoke nuisance had been abated.

The steam charts showed a very steady pressure. A moment's study will show that there is little or no inrush of cold air during stoking. The magazine is kept full and when being replenished there is little draft to induce a rush of air on the comparatively small area of exposed boiler surface. A reasonable attention to the side draft doors (which allow a current through the perforated tile, D, of the magazine) to the ashpit doors (bottom draft) and to the center-pin door (checking draft), secures a very regular combustion, while a brief slicing will make the boiler pick up at once.

During the first winter's run a saving of just about 10 T. a month was effected over the old installation. With the second year half over, this saving has been completely verified by a number of comparative runs, when it has been advisable for one reason or another to change off boilers for a short time. It seems evident that this saving is the result of greatly improved circulation, which the new arrangement induces. In the ordinary return tubular boiler such circulation as exists is probably in the cross plane—that is, up the sides of the circular shell. At best, a constant turmoil must be going on, with cross currents and counter currents. It is established beyond doubt that in the apparatus under discussion a rapid circulation from front to back is set up. This is proved by the polished condition of the water tubes inside, and also by another incident which will be mentioned later. If this reasoning is correct, our moderate-priced old friend of the small plant —the return tubular boiler—is likely to be with us for quite a spell yet, with the help of this, or a similar auxiliary.

Troubles and Alterations

The company which furnished and installed this patented apparatus made the connection to the boiler head-plate with an elbow and nipple, using a lock-nut and copper gasket on the latter, both on the inside and outside of the plate. It seemed impossible to make the joints at these points absolutely tight—probably owing to expansion movement in the water-grates. After the first winter's run, this ell and nipple were removed, and a large tee and nipple substituted, the latter being rolled into the head-plate and peened over inside. The opposite opening of the tee, through which the rolling was done, was stopped with a heavy brass plug. A swing joint of ells was also put in at the rear end of the long pipes leading to the rear connections. All leaking troubles ceased.

When the boiler was down recently, to be washed out, two bright spots appeared at the rear inside connections when the front manhole was removed and the spot-light thrown in. They proved to be the inside surfaces of the brass plugs, which had been polished like a mirror by the circulation of the boiler. At this time

there was found a little annular ring or heap of scale around the boiler blowoff—21 lb., weighed wet. That was the entire collection after a 3-mo. run.

It will be noticed that the charging doors are much higher than in the usual boiler front. It was contended that the fireman would kick. The writer took the opposite view and believed that this opportunity to straighten the back would be welcomed. It is only necessary to listen to the grumbles when he has to stoop and rabble the old style fire to know which is the easier job; also, which is the cooler job.

While these results have been attained, it must be remembered that the steam requirement of this plant is not excessive. Although experience shows that the furnace responds almost instantly to the regulating devices, it has never had to be really forced to do its maximum.

The power equipment consists at present of one compound duplex steam pump, 12 by 18 by 8½ by 12, for the hydraulic system, one vertical 9 by 9 engine which drives the cash-blower, one small boiler feed pump 6 by 4 by 6, and the make-up of live steam for house heating, which varies from 2 to 6 lb., depending on the weather. Two direct driven steam-electrical generating units are not at present in use. The store buys its light in winter and its power and light in summer. An average of 90 lb. pressure is carried from 7 a. m. to 6 p. m., and is allowed to drop to about 30 lb. during the night. It has not been demonstrated just how large a load the boiler would carry with very active firing. Under the present load, the magazines do not require to be "lined up" oftener than once every 2 or 3 hr.

The average coal burned per day of 24 hr., taking the actual figures of over one and a half years, is 1.574 T. This is an excellent result.

No regular evaporation tests have been made at the plant. The main object has been to abate the smoke nuisance, and the fuel saving followed as a consequence of the improved circulation and better combustion. It is not the purpose of this article to discuss the finer points of evaporation. This boiler furnishes the required amount of steam with much less fuel than formerly, and with no overloading. It would be perfectly practical to enlarge the water-grates and thus obtain more heating surface if it became desirable to steam harder, but the present outfit is quite sufficient for the work which it has to do.

Utilizing Waste Heat and Gas for Power Generation

ESTIMATING QUANTITY OF WASTE GASES IN PRODUCTION OF PIG IRON AND WHAT MAY BE EXPECTED FROM THESE GASES IN STEAM GENERATION. BY F. G. CUTLER

IN ORDER to show the relative proportion of the energy in the shape of heat or power required for the manufacture of steel that is utilized from the fuel by-products of the manufacturing process, the following figures have been prepared showing the quantity of heat derived from the by-products of the manufacture of pig iron.

In the production of one ton of pig iron, from under 1800 to over 3000 lb. of coke are used, this variation being due to difference in metallic content of the charge, condition of the furnace lining, quality of coke, etc. The heat energy of this coke is utilized in the reduction of the ore to pig iron and changing the impurities to a slag; a part is lost in radiation, and approximately half is delivered at the top of the furnace in the shape of gas for use under boilers for the production of steam, or in gas engines for the production of power. The gas has also been used in soaking pits, in by-product oven heating, ladle drying, etc., and other uses have been proposed, but by far the greatest quantity has been used under boilers.

It has been only within the last few years that blast-furnace gas has been considered to have any material value. In the past there has been no recognized method of determining whether or not a blast-furnace plant has been guilty of wasteful practice, or if guilty, what the extent of this waste might be, and it is the intention of this paper to propose a standard method of comparison of total combustion efficiency both with the idea of determining, for any particular plant, the relative efficiency, from day to day or month to month, as well as for the comparison of one blast-furnace plant with another, for the information of the management and the engineers in determining the necessity for improvement in equipment or personnel.

HEAT AVAILABLE FROM THE BLAST FURNACE

IN PROPOSING this standard comparison, reference is made to Fig. 1, which is taken from Mr. Brassert's paper on Modern Blast Furnace Methods, published in the year book of the American Iron and Steel Institute in 1914. This chart shows the effect of variation in coke rate upon the heat value of blast furnace gas at 62 deg. F. As blast furnace gas leaves the top of the furnace it usually has a temperature of from under 300 to over 600 deg. F., generally averaging about 400 deg. F.

At this latter temperature, the sensible heat of the gas is equivalent to about 8 B.t.u. per cubic foot of gas at 62 deg. The B.t.u. per cubic foot of blast-furnace gas according to Brassert is $62.5 + 0.016R$, where R = pound of dry coke per ton of pig iron; and including sensible heat of the gas at 400 deg. F., would be equal to $70.5 + 0.016R$. The cubic feet of gas per ton of pig iron (as shown by Brassert) is equal to $71.4R$, so that in the top gas from a furnace at 400 deg. F. the B.t.u. per ton of iron is $1.142R^2 + 5033.7R$. Brassert also gives the cubic feet of air per pound of coke equal to $51.4R$, so that both gas production and the blast requirement bear a direct ratio to the coke consumption of the furnace per ton of iron. The figures given in Mr. Brassert's paper, so far as the author has been able to discover, are applicable to all blast furnaces using coke as fuel.

HEAT REQUIRED FOR THE STOVES

THE BLAST is heated in stoves under pressure, and the heat required per cubic foot of blast is proportional to the rise in blast temperature in the stove, and inversely proportional to the efficiency of the stove, which is usually considered to average 60 per cent. After the necessary gas is used to heat the blast, the remainder can be measured in the shape of power. Any increase in stove

or boiler efficiency or reduction in leakage of gas, etc., is reflected in increased surplus power, and as we are largely interested in the surplus power, after the blast furnace requirements are satisfied, any error in the assumptions relative to the efficiency of the stoves is of minor importance, particularly as the stoves use the smaller fraction of the total. The blast supplied from the blowing engines is heated by compression to about 150 deg. F., varying somewhat with blast pressure, etc., and is usually heated in the stoves to from 1150 to 1350 deg. F. In the following calculations it has been assumed that 0.02 B.t.u. are required per cubic foot of blast per deg. F., that the blast is heated in the stoves to 1250 deg. F., that the average overall stove efficiency (i.e., ratio of heat given to the blast to the heat in the gas) is 60 per cent and that 55 cu. ft. of blast are heated per pound of coke charged.

The heat required in the gas for heating the blast for one ton of pig iron to a temperature of 1250 deg. F. can therefore be expressed by the following formula

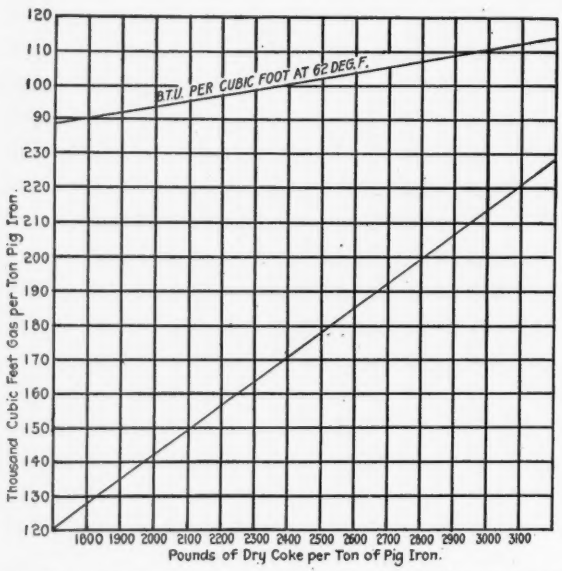


FIG. 1. EFFECT OF COKE RATE ON PRODUCTION OF BLAST FURNACE GAS

where H = B.t.u. per lb. of coke burned in the blast furnace.

$$H = \frac{(1250 - 150) \times 0.02 \times 55R}{0.60} = 2020R$$

The heat in gas per ton product after the blast is heated is therefore, $1.142R^2 + 3013.7R$. For other top temperatures and blast temperatures the constants will change slightly.

Heat Required for Gas-Fired Boilers

In order not to enter into the discussion of the relative merits of steam vs. gas engine, surplus uncooled gas, after the stoves are heated, will be assumed to be used under boilers. In one boiler horsepower-hour there are 33,305 B.t.u., and assuming that the "standard" efficiency of blast-furnace-gas-fired boilers is 66.6 per cent, in one boiler horsepower-hour $\frac{33{,}305}{0.666} = 50{,}000$ B.t.u. would be required in the gas, so that the boiler hp.-hr. per ton would be $\frac{\text{Surplus B.t.u. per ton iron}}{50{,}000 \text{ B.t.u.}}$. As the blast furnace product is usually expressed in tons per day the average boiler horsepower per hour generated from blast furnace gas under the above conditions can be expressed by the formula:

Average boiler horsepower per hour per ton of pig iron per day

$$= \frac{1.142R^2 + 3013.7R}{50{,}000 \times 24}$$

In assuming the standard efficiency of 66.6 per cent for boilers and 60 per cent for stoves, it should not be understood that these are the maximum efficiencies that can be attained, but rather that they are taken as a standard of comparison and represent average practice that can be maintained in a fairly modern plant which is correctly designed, and which is operated by reasonably intelligent men.

Using the above, Fig. 2 has been prepared. This chart also shows the per cent of top gas required for heating the blast to an average of 1250 deg. F. with the stoves of 60 per cent total efficiency. This chart can be used by the blast furnace superintendent or engineer to determine the horsepower that should have been generated from gas for any period. From the actual results as shown by a meter on the boiler feed line, after deducting an allowance for steam generated by coal firing (usually small) or for gas used by gas engines, it will be possible to determine whether the total efficiency, including stoves and boilers, is above or below the standard.

The following table shows the boiler horsepower-hours per ton of pig iron for several coke rates as calculated from the above formula.

Pounds of Coke per Ton	Boiler Horsepower-Hours per Ton Product	Boiler Horsepower-Hours per Ton per Day
2000	211	8.8
2200	242	10.1
2400	276	11.5
2600	310	12.9
2800	348	14.5
3000	386	16.1

To furnish the blast to the furnace with either high-pressure condensing, turbo-blowers or reciprocating steam engines requires about 70 boiler hp.-hr. per ton of coke burned in the blast furnaces, and to operate the various furnace auxiliaries, such as pumps, air compressors, steam bells, mud guns, hoists, etc., requires from 15 to 25 boiler hp. per ton of product, so that after the furnace requirements have been met, there is available for the generation of power from 100 to 250 boiler hp.-hr. per ton of pig iron, depending on the coke burned in the furnace.

At 2 kw. per boiler hp.-hr. this means that from 200 to 500 kw.-hr. per ton of pig iron is possible with steam equipment from the surplus gas from the blast furnaces.

Heat Required for Manufacture of Steel from Pig Iron

The manufacture of steel from pig iron in the open hearth requires heat for melting scrap and fluxing the

impurities, and power for the various operations incident to this process. The quantities of heat and power required vary materially with different plants on account of difference in equipment, practice, etc., but for the purpose of this paper it will be assumed that a ton of ingots requires one ton of pig iron plus enough scrap to offset the losses and this work requires from 5,000,000 to 9,000,000 B.t.u. and an expenditure of from 20 to 30 kw.-hr. per ton. This ton of ingots will make about 0.85 ton of blooms, and the heating in soaking pits will require from 1,500,000 to 3,500,000 B.t.u. per ton of steel depending upon the temperature of the steel arriving at the pits, rate of operation, etc., and the rolling of the ingots into blooms will require from 40 to 60 kw.-hr. per ton. From the blooming or slabbing mill the material, usually reheated at an expenditure of from 2,500,000 to 6,000,000 B.t.u. per ton, is furnished to finishing

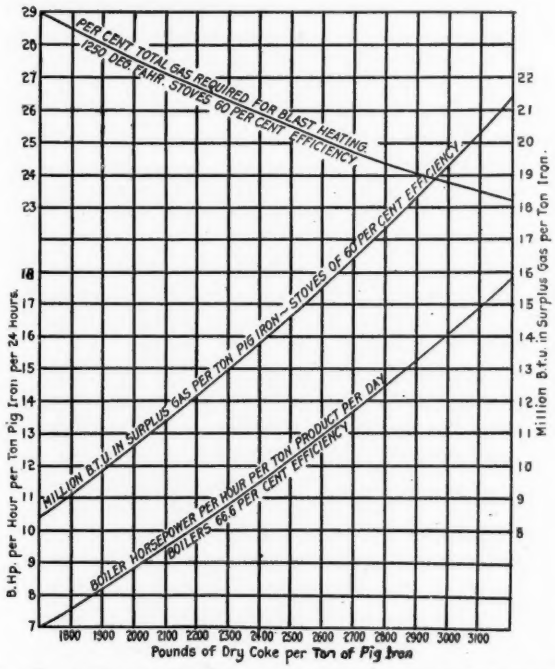

PER CENT TOTAL GAS REQUIRED FOR BLAST HEATING
1250 DEG. CAHR. STOVES 60 PER CENT. EFFICIENCY
MILLION B.T.U. IN SURPLUS GAS PER TON PIG IRON — STOVES OF 60 PER CENT EFFICIENCY
BOILER HORSEPOWER PER HOUR PER TON PRODUCT PER DAY
BOILERS 66.6 PER CENT EFFICIENCY
B.Hp. per Hour per Ton Pig Iron per 24 Hours.
Million B.t.u. in Surplus Gas per Ton Iron.
Pounds of Dry Coke per Ton of Pig Iron
1800 1900 2000 2100 2200 2300 2400 2500 2600 2700 2800 2900 3000 3100

FIG. 2. EFFECT OF COKE ON PRODUCTION OF POWER FROM SURPLUS BLAST FURNACE GAS

mills, the power required, depending on the reduction of section, temperature of rolling, etc., varying from 35 to over 300 kw.-hr. per ton.

Heat Balance

THE FOLLOWING table gives an example of the approximate heat balance of one ton of pig iron as used in the steel plant, using average figures, and based on an average coke consumption in the blast furnace of 2500 lb. of coke per ton of product.

Necessity of Heat Conservation

FROM this table it will be seen that the total heat from the by-products of a ton of pig iron is more than sufficient to finish the average ton of steel, but upon inspection of the table it will be found that the heating requirements have not been met from tar and by-product gas, while the average power requirements are more than met from blast-furnace gas and coke breeze.

HEAT BALANCE FOR MANUFACTURE OF ONE TON OF PIG IRON

From the coke plant delivering one ton of coke there results the following fuel by-products for consumption in the steel plant after the heat and power requirements of the by-product plant have been met:

12 gal. tar at 162,500 B.t.u. per gal., B.t.u.	1,950,000	
30 lb. of coke breeze at 12,000 B.t.u. per lb., B.t.u.	360,000	
10,000 cu. ft. gas at 500 B.t.u. per cu. ft. (net value), B.t.u.	5,000,000	
Total per net ton coke		7,310,000
Heat available per ton pig iron	B.t.u.	B.t.u.
In tar from by-product plant	2,435,000	
In coke breeze from by-product plant	450,000	
In surplus gas	6,250,000	
Surplus from by-product plant		9,135,000
In blast furnace gas		19,635,000
Required for blast heating	5,000,000	
Required for blowing equipment	4,400,000	
Required for blast furnace operation	1,000,000	
Required for total blast furnaces		10,400,000
Surplus from blast furnace plant		9,235,000
Total heat energy from by-products		18,370,000
Heat required for steel plant		
Open hearth (pig iron to ingots)		
Melting (approx.)	7,000,000	
Power, 25 kw. at 25,000 B.t.u. per kw.-hr.	625,000	
Total heat consumption		7,625,000
Roughing Mill		
Heating (approx.)	2,000,000	
Power, 50 kw.-hr.	1,250,000	
Total		3,250,000
Finishing Mill		
Heating (approx.)	4,000,000	
Power, 100 kw.-hr.	2,500,000	
Total for finishing		6,500,000
Total heating requirements	13,000,000	
Total power requirements	4,375,000	
Total		17,375,000

One of the most important problems of the steel plant manager and engineer is so to regulate the production and consumption of the various fuels occurring as a by-product of steel-plant manufacture that the consumption of raw coal in producers or under boilers that would otherwise be sent to the by-product plant is a minimum, for the reason that the by-product from the coal, coked in the by-product plant, usually exceed any possible return as fuel.—Abstract of paper appearing in Mechanical Engineering to be presented at the spring meeting of the A. S. M. E. at Atlanta, May 8 to 11.

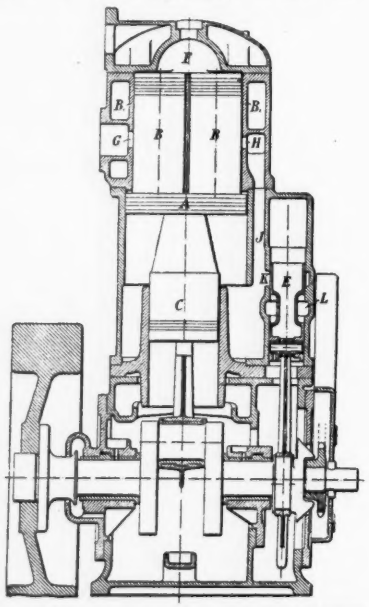
A THOROUGH survey of the fusibility of coal ash from various coals of the United States has been completed by the Bureau of Mines and the data tabulated for publication as a bureau bulletin. The method for fusibility of coal ash as developed by the bureau has been adopted as a tentative standard method by the American Society for Testing Materials. An alternate rapid method known as the micro-meldometer method has been proposed. The bureau has assembled the equipment for this alternate method and in co-operation with a number of other laboratories a series of tests comparing the two methods is being made. In co-operation with the fuel section of the bureau, it is proposed to investigate the relation of laboratory fusibility tests to clinker formation in burning coal under actual operating conditions.

PLANS ARE being prepared by a committee from various government departments for a standardized method of purchasing and testing coal for Government use. In view of the chaotic condition of coal purchasing since 1917, such a method, if in form to be applied also by private purchasers, should go far to enable an engineer to know what he is getting for fuel and to insure that he will get what he pays for.

The Record Combustion Engine

WITH TWIN CYLINDERS AND COMMON COMBUSTION ENGINE. BY J. H. BLAKEY

AT THE RECENT Shipping, Engineering and Machinery Exhibition held in London, England, the Record Engineering Co. showed a petroleum motor of a new type, having twin cylinders communicating at their upper end by a common combustion chamber. In these cylinders move two pistons mounted on a third, which acts in the upper part of the engine casting as an air pump. The illustration shows a section of the motor, which works on the two-cycle principle. The two motor pistons B are mounted on the third A, of large diameter. This is in one piece with the plunger C, which moves in a cylindrical guide, and is fitted with piston rings. The common combustion chamber is at F. The openings H are for admission



VERTICAL SECTION OF RECORD ENGINE

and G those for escape. This arrangement is for the cleaning out of the cylinders after each stroke.

Pistons being in the position shown in the figure, the charge is ignited. In the downward movement the gaseous mixture beneath the piston A is compressed in the space below it and in the passages J and H. When the Pistons B approach their lower limit, the escape openings G are opened first, to allow the escape of the burnt gas. Soon after, the openings H are uncovered and the charge compressed under the piston A is introduced into the cylinders by way of the combustion chamber F. At the moment the pistons begin to rise the admission valve E is lifted, putting the enclosed space of the engine casting into communication with the carburetor by the passage L and the opening K, so that the space below A is filled, during the up stroke, with combustible mixture to be compressed during the next down stroke. When these engines are built with a larger number of pistons the arrangement of the parts is somewhat different but the principle is the same. They work with gasoline, petroleum or gas, and are built in sizes up to 250 horsepower.

Municipal Diesel Engine Plant

NOVEL SIGNAL USED FOR WORN-OUT OIL IN OIL ENGINE PLANT AT PEETZ, COLO. BY W. L. HOLDEN

IN THIS plant are two units, one a 25-hp. Fairbanks Morse engine belted to a 15-kv.a., General Electric 3-phase generator at 440 v., and also driving a pump; the other a three cylinder Anderson 60-hp. engine direct connected to a 48-kv.a., General Electric generator at 2300 v. This unit also drives a pump through a 220-v. motor.

Eighteen months ago, when I first came to the plant, the Anderson unit was just being completed, and the Fairbanks Morse unit was badly overloaded. It was operated single-phase by a boy who had been in charge for 2 yr. and the outfit was going to pieces. The council asked me to do the best that I could with it until the larger unit could be started, and that in the winter they would get an expert to overhaul the older outfit.

This did not suit my ideas, so I took off the air port plate and found 8-penny nails used for cotter keys, the nuts being so loose that I took them off with my fingers. Taking out two shims on each side, I tightened the nuts as much as could safely be done with a 36-in. wrench, put in a new air port valve, cleaned out the carbon, put in three new rings, connected up to run 3-phase and stepped up to 2300 v.

I burned up the cheap, thin oil that had been used and got some real oil that would not break down under heat. That unit has since been running as smooth as one could wish and is carrying all the day load.

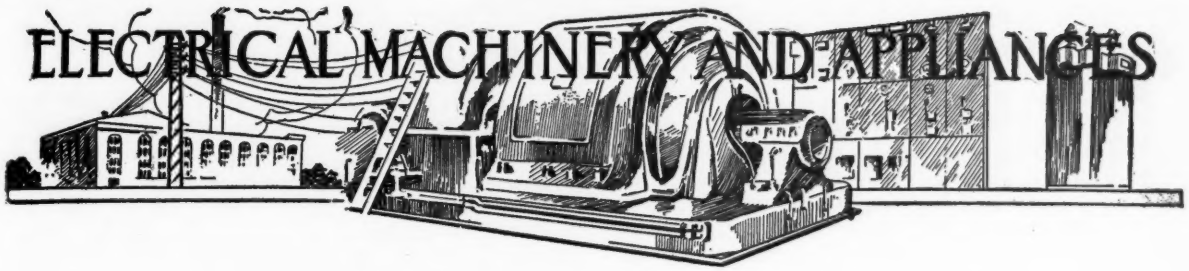
The Anderson unit is used for the peak load and for emergencies, but is handicapped by the fact that it is too large for the work. The peak never runs over 23 kv.a. about 9 2/5 amp., at 2300 v., which is too small for a 60-hp. engine. It is using under these conditions about 3 gal. of fuel oil per hour and about ½ gal. of lubricating oil. Under normal loads, the small unit uses about 1 gal of fuel oil per hour and 1 gal. of lubricating oil in 24 hr. The entire cost of operation of the plant for the month of December was $338.

This cost would have been considerably higher but for the fact that we are using a thorough filtering system for the lubricating oil which I invented and have patented. By this means we can use the oil over repeatedly until it is wornout or burned up.

The method adopted to keep track of the condition of the oil was to connect a 10-w., 110-v. lamp with one terminal connected to the line, the other to the engine frame. The other lead from the line was connected to a brush, bearing on the crank shaft. As long as the oil was in good condition, the lamp would not light; but when it was time to change oil, the lamp would flicker and flash. It was then time to dump the lubricating oil into the fuel tank and burn it for fuel. I am now using graphite grease in the grease cups, so the method will not work, as the lamp stays lighted all the time.

With the method of filtering and testing used, the bill for lubricating oil was reduced from $80 a month to $30.

WHEN SOMETHING good can be seen in the worst, life becomes brighter.



Direct Current Armature Windings---II

METHODS OF CALCULATION AND DETAILS REGARDING CONSTRUCTION AND METHOD OF INSULATING. BY MARIN PHILLIPS

HAVING EXPLAINED in the first part of this article the difference between the wave winding and the lap winding, we will now show the method of calculation involved in layout of such types as the simplex, duplex, triplex and quadruplex windings.

Figure 7 shows the method of connecting the coils to the commutator for lap and wave windings, in which M equals the number of independent windings on one armature. Each one will be taken up and discussed in the order named above.

In making winding calculations for an armature, there are certain rules and formulas which are made use of. The most important of the formulas is the electromotive force equation.

$$E = \frac{Z\,S\,F\,P}{10^8 \times 60 \times C}$$

in which E = the total voltage
Z = the total number of conductors in the armature
S = the number of revolutions per minute
F = the number of lines of force or flux per field pole which is usually about 40,000 lines per sq. in.
P = the number of field poles
C = the number of armature circuits
10^8 = the lines of force that will produce one volt when cut by one conductor in one second.

In laying out armature winding, the following nomenclature will be found convenient for a lap wound armature:

y b = back pitch in terms of inductors.
y f = front pitch in terms of inductors.
s = the number of inductors or coil sides.
k = a constant to be selected.
l c = long chord.
s c = short chord.
m = number of windings.
m = 1 for a simplex winding.
m = 2 for a duplex winding.
m = 3 for a triplex winding.
m = 4 for a quadruplex winding.
m = 6 for a sextuplex winding.
y k = commutator pitch.
n k = the number of commutator bars.
n c = the number of circuits through the armature.
n s = the number of slots in the armature.

y b must always be a whole odd number.
y f must always be a whole odd number.
s must always be a whole even number.

$y\,k = m.$

$n\,k = s \div 2.$

$$y\,b = \frac{s}{p} \pm k.$$

$y\,f = y\,b \pm 2 \times m.$

$n\,c = p \times m.$

Each single coil contains two inductors as shown in Fig. 8a, but on some machines there are more commutator bars than slots. We will use for an example an armature with twice as many commutator bars as slots.

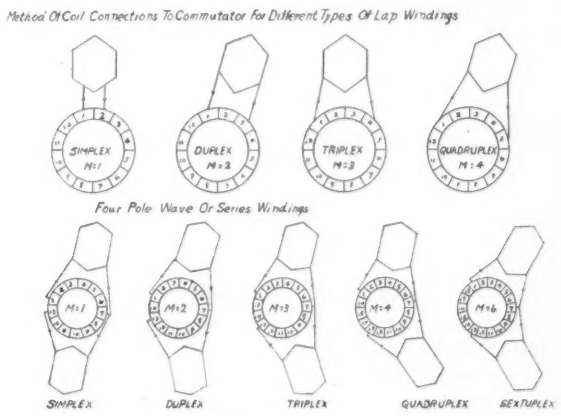


FIG. 7. METHOD OF COIL CONNECTIONS TO COMMUTATOR FOR DIFFERENT TYPES OF LAP WINDINGS

In this case we would use two coils in each slot, then s would equal four as shown in Fig. 8b. They may be put in the slots separately or taped together and the four leads brought out with a different color or sleeving, so they may be easily distinguished. When connecting them to the commutator, or an armature with three times as many commutator bars as slots, we would use three coils in each slot, Fig. 8c. It does not matter how many turns of wire each coil has; that is, a single coil with one turn would have two inductors, and if it had 10 turns it would still have two inductors. It is very important not to get the term "inductor," which we will use in our calculations, confused with the turns of wire in the coil. Again, we might pick up a coil, as

shown in Fig. 8d and state off-hand, that the number of inductors equals four, the same as Fig. 8b, which is not the case.

Selecting Wire Size

On an armature that has to carry a heavy current, a wire has to be selected large enough for the coils to carry the current safely without overheating. Suppose an armature is selected that would require a No. 10 wire for the coils. This would make the coil very stiff and hard to handle so to see what we can substitute for the No. 10 wire we refer to a table of equivalents of wire sizes. We find that two No. 13 wires are equal to one No. 10, and a coil made of two No. 13 wires in parallel is much easier to handle and to get in the slots than if it is made of one No. 10. We would then have a coil such as is shown in Fig. 8d in which the number of inductors would be two. Again, the wire selected for a given armature might be so large that it would be better to make the coils out of three small wires in parallel

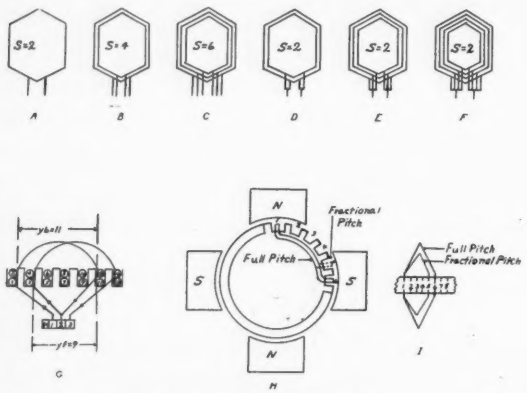


FIG. 8. TYPES OF ARMATURE COILS AND DIAGRAMMATIC DATA IN REGARD TO "PITCH"

as in Fig. 8c in which the number of inductors still equals two.

Actual Calculations

Now let us proceed to figure out and connect up the winding as shown in Fig. 5. We will assume that it is a 5-hp. 4-pole, 1200-r.p.m., 240-v. machine. The first thing to do is to see how many conductors will be required for the armature. By referring to formula No. 2, and substituting known values, we find that

$$Z = \frac{100{,}000{,}000 \times 60 \times 4 \times 240}{1200 \times 1{,}000{,}000 \times 4} = 1200 \text{ conductors.}$$

This assumes 1,000,000 lines of force per pole.

Since there are two conductors for each turn, we will require 600 turns for the complete armature, and 24 coils divided into 600 will equal 25 turns per coil. The full load current of a 5-hp., 240-v. motor is about 20 amp.; but as this armature is lap wound and has four parallel circuits, the wire for the coils need be only of large enough capacity to carry one-fourth of the armature current, which will be 5 amp. By consulting a table of carrying capacity of wires, it will be found that a No. 16 or 17 wire will be large enough.

The next step will be to find the throw of the coils, which is the number of slots spanned. When the coil spans the exact distance between the centers of adjacent field poles, it is called a full pitch winding; that is, for a 24-slot armature the coils should lie in slots one and six, see Fig. 8h. In cases where a coil has less than full pitch, it is called a fractional pitch or short chord winding. The fractional pitch windings have two very great advantages to their credit. First, they span one or two slots less than a full pitch winding, and by referring to Fig. 8i, it is evident that a great saving in copper can be made by using a fractional pitch winding. Second, the currents in the neutral zone partly flow in opposite directions, which tends to reduce armature reaction. It must be remembered that the coils cannot be chorded enough to bring both sides of the coil under the same pole. Under this condition the induced E. M. F.'s will oppose each other, therefore making the coil ineffective. The poles usually cover about 60 per cent of the armature circumference and by referring to Fig. 8h it is shown that if the coil was chorded to slots one and four it would bring both sides of the coil under one pole. Whether an armature is wound full or fractional pitch depends on the design of the armature and no changes should be attempted without first consulting the manufacturer of the armature. When the coil is chorded, more turns have to be added in order to generate the required voltage.

To find the coil throw for Fig. 5 the following formula is used: $y\,b = \frac{S}{P} \pm K$. As the armature has 24 coils and each coil has two inductors, S will equal 48, P equal 4 and K is a value to be chosen. By substituting, we find $y\,b = \frac{48}{4} \pm K = 12 \pm K$ and as y b must be a whole odd number we may substitute one for K which would make $y\,b = \frac{48}{4} \pm 1 = 12 - 1 = 11$ or $12 + 1 = 13$. There are two numbers to choose from, 13 for long chord or 11 for short chord; but before choosing 11 or 13, a set of slots should be marked as shown in Fig. 9 and two inductors placed in each slot. Number the top ones with an even number and the bottom ones with an odd number, as shown. Now suppose 13 is selected for y b, then from inductor No. 1, which is in slot No. 1, the addition of 13 will advance to inductor No. 14, which is in slot No. 7, making it one slot over full pitch, which is undesirable. By taking 11, it advances from inductor No. 1 to No. 12, which is in slot No. 6, making it a full pitch coil. Figure 9 will be of assistance in selecting the constant K. From the foregoing it is obvious that the first thing to do when laying out a winding, if the coil pitch is not known, is to mark a set of slots, add the inductors, and divide the number of inductors by the number of poles, and select a number for K that will make y b an odd whole number. It can then be decided whether long or short chord is desired.

After y b is obtained, it is used for obtaining y f according to the following formula: $y\,f = y\,b \pm 2\,m$. As this is a simplex winding $m = 1$; then $y\,f = 11 \pm 2 \times 1 = 13$ or 9, again giving us two numbers to choose from. If y f selected is greater than y b, a retrogressive winding will be obtained, or a winding that laps back

and proceeds around the armature in a counter-clockwise direction. If y b selected is greater than y f, a progressive winding, or a winding that advances around the armature in a clockwise direction, will be obtained, as in Fig. 5(April 15th assue), where 11 was selected for y b and 9 for y f. Figure 8 shows the difference between y b and y f.

When y b and y f have been found, the winding step (Fig. 5a) should be drawn before attempting to make any connections to the commutator. The writer has seen windings designed that did not come out right, and the mistake did not show up until the last coil was to be connected to the commutator. To construct the winding step, draw a commutator bar and call it No. 1. Next, draw a line to inductor No. 1 and add y b to it, which will advance to inductor No. 12, then back to commutator bar No. 12, then subtract y f, which is 9, from inductor No. 12 which will lap back to inductor No. 3, and so on until all the inductors have been drawn. If the winding is done correctly it will close on itself at commutator bar No. 1.

Perhaps a little explanation on the winding step after inductor No. 39 is reached will make it more easily understood. When inductor 39 is reached by adding y b it will advance to inductor No. 50, but the armature has only 48 inductors, so by subtracting 48 from 50, inductor No. 2 is obtained.

Making Coils

Now that the coil throw has been obtained, the coils may be made, which is a simple job if one of the old coils was saved to measure by, if not, measurements will have to be taken of the armature, but for a trial only make two coils and put them in slot one and six and see if they fit, that is with the necessary insulation in the slots, taking care not to have the coils too long, as they might rub on the end frame when the armature is rotating, and again, if the coil is too long it will come too close to the back of commutator.

It was found in the calculations that No. 16 or 17 wire will be large enough for the coils as it is always desirable to have the coil fit snug in the slots so as not to have the coil vibrating or moving in the slot when the armature is rotating. Suppose the two trial coils were made out of No. 17 wire and that the coils fit loose in the slots; it would then be advisable to make two more coils out of No. 16 wire and try them in the slots, and if they go in without very much forcing they will be the ones to use. The 24 coils can then be made up out of No. 16 wire.

Methods of Insulating

There are two general types of armature slots known as the open slot, Fig. 9a, and the partly closed slot, Fig. 9b. If the armature in question has open slots and the repair shop is not equipped with a coil making machine, it is best practice to order the coils from the manufacturer. If the slots are partly closed, the coil cannot be placed in the slot all at once, and such coils can easily be made up on forms which can be made in any shop. When the coils are made, the armature core at the ends of the slot and the back of commutator must be well insulated with fish paper and linen tape. The core must be built up until it is a little bit higher than the bottom of the slot, so that when the coils are drawn taut with the band wire, they will not rest on the corner of the slot, as would be the case if the ends of the coils are drawn down farther than the center.

Before starting to insulate the armature, each slot should be inspected to see if it is smooth and free from projecting laminations, which will cut through the insulation. All such slots must be filed smooth. If the armature has been burned out, it is not uncommon to find badly burnt slots with small pieces of copper welded in the iron. Such obstructions must be closely watched for to prevent giving trouble when the armature is completed. It is always good practice to test the commutator for grounds and short circuits between bars, before placing the coils on the armature.

The slots may be insulated by placing a fish paper cell 0.016 in. thick next to the iron, having inside of it an empire cloth cell 0.008 in. thick. Both cells should be an inch longer than the slots, so as to protect the wire from the iron at the corner of the coils and should be wide enough to reach up to the opening of the slot, as

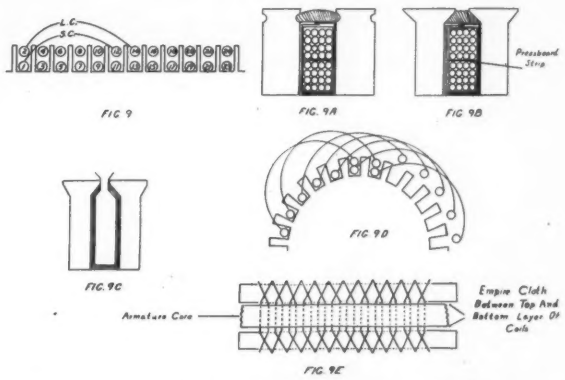


FIG. 9. DETAILS OF ARMATURE SLOTS AND METHODS OF INSULATING

shown in Fig. 9c. Inside of this empire cloth cell place another fish paper cell 0.008 thick, and have it wide enough to extend above the top of the slot about 1½ in., to protect the insulation of the wire while it is being inserted in the slot. Between the bottom and top coil place a strip of press board 0.032 in. thick cut wide enough to fit taut in the slot. This will be sufficient insulation up to 500 v. for partly closed slots. If the slots are open, the coils are taped and treated before being put in the slots and will therefore not require much slot insulation. A fish paper cell 0.011 in. or 0.012 in. thick in the slot to protect the insulation on the coil will be sufficient. By placing the fish paper cell next to the coil and rubbing the coil with powdered soapstone or paraffin wax (powdered soapstone is best) the coil will stand quite a bit of forcing without wrinkling the cell.

The cells may now be placed in the slots, but only place one side of the first five coils in the slot, as the bottoms of some other coils go in first. When the bottom of the fifth coil has been put in the slot, then the top of the sixth coil will go in on top of it as shown in Fig. 9d. Then the insulating cells may be cut off flush with the top of slot and folded down on the coil, and the slab wedge put in place as shown in Figs. 9a and 9b. A strip of empire cloth wide enough to reach from the

edge of slot to the ends of the coils, is placed between the bottom and top layer of coils to insulate them where they cross. When the coils are all put in the slots, the coil leads are separated; that is, the start of all the coils are all put in the bottom of commutator slots, and the finish of all the coils are raised up so a strip of insulating material can be placed between the bottom and top leads. Facing the coil end where the leads are brought out, the lead on the left side of the coil will be called the start of the coil, and the one on the right, the finish. The top row of leads may now be connected to the commutator, taking care to have the finish lead connected one bar to the right of the starting lead all the way around the commutator. Then the leads may be soldered to the commutator, which should be about 2 or 3 in. lower than the other end of the armature, to help prevent the solder from running down the back of commutator and causing short circuits.

Indicating the Total Power from Several Stations

A System of Load Indication Which Gives Dispatcher All Necessary Information at a Glance. By H. P. Sparkes

IN PRACTICALLY all central station companies operating two or more generating plants to feed a common load, the division of load between the generating stations and substations is determined by a load dispatcher at some convenient central point. The usual method for ascertaining at the load dispatcher's office

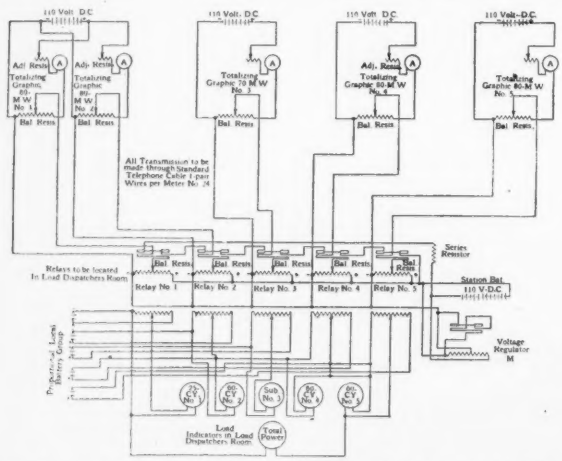

110 Volt D.C.
Adj. Resis.
Totalizing Graphic 80-M.W. No. 1
Bal. Resis.
Totalizing Graphic 80-M.W. No. 2
Totalizing Graphic 80-M.W. No. 3
Totalizing Graphic 80-M.W. No. 4
All Transmission to be made through Standard Telephone Cable 1 pair Wires per Meter No. 24
Relays to be located in Load Dispatchers Room
Relay No. 1
Relay No. 2
Relay No. 3
Relay No. 4
Relay No. 5
Series Resistor
Station Bat. 110 V.D.C.
Voltage Regulator M
Load Indicators in Load Dispatchers Room
Total Power

FIG. 1. CONNECTIONS FOR A TOTALIZING LOAD INDICATING SYSTEM

the loads on the generating stations involves the use of telephone equipment, generally with direct lines to each station and substation. The personal error involved in telephoning is, however, sometimes considerable, causing confusion in the power systems. It is convenient for the load dispatcher to have continuously before him some indication of the load on each of the stations, as well as the total load on the system. A system of load indication which will give the dispatcher all the necessary information at a glance has accordingly been developed.

It is important that such a system should involve the minimum number of wires between the stations and the load dispatcher's office. The system proposed operates with only two pilot wires. To permit the use of ordinary telephone cables without interrupting the telephone service or overloading the wires, a current limit of 0.1 amp. and a voltage limit of 100 v. has been established. With these limits, it is possible to maintain private wires through the telephone company cables and transmit the various totalizing indications from the several stations to the load dispatcher's office without interruption. By suitable adjustments, the same pair of pilot wires can be made to carry the load indication, a 60 or 25-cycle wave for frequency indication, and a telephone conversation, simultaneously.

As the resistance of a telephone wire is high and is not constant, the only practical scheme of load indication over a telephone cable is a null method in which the current is normally zero. The scheme proposed is based on the potentiometer principle, in which the voltages from two instruments are balanced against each other, so that no current flows as long as a balance is maintained. The potentiometer must be automatically adjusted, so that when a change is produced at the sending end of the pilot wire, the resulting unbalance will affect the equipment at the receiving end in such a way as to raise or lower the voltage at this point until a balance is again established.

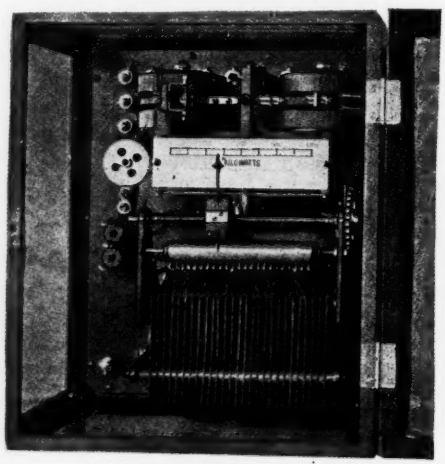


FIG. 3. DISPATCHERS' POTENTIOMETER RELAY

A load transmitting system operating on the potentiometer scheme is shown diagrammatically in Fig. 1. This diagram covers a system which includes one power station generating both 25 and 60-cycle power, the two frequencies to be indicated separately at the load dispatcher's office, two other generating stations operating at 60 cycles and a substation whose load is to be indicated at the dispatcher's office but not included as an additional item in the total, since it draws all its power from the three generating stations. This involves five separate load indicators in the dispatcher's office, as well as a sixth indicator showing the total power.

This potentiometer indicating scheme may be divided for purposes of analyses into four separate divisions:

1. A means for impressing a voltage on a pair of pilot wires which is exactly proportional to the load at the generating station. This device consists of a totalizing graphic wattmeter, equipped with a special balancing resistor.

2. A means at the dispatcher's office for automatically balancing the voltage which is impressed on the pilot wires by a device whose position at the point of balance accurately corresponds to the load at the corresponding generating station. This device is known as the relay potentiometer.

3. A means for producing a visual indication corresponding to the position of the relay potentiometer. This consists of a voltmeter placed in the position which is most convenient for the load dispatcher, calibrated in kilowatts.

4. An additional voltmeter, calibrated in kilowatts, indicating the total power in the whole system.

Totalizing Graphic Wattmeter

The instrument used to send out the impulses over the pilot wires from the power station must be made to totalize the power in the station without complicated or delicate adjustments, making it unnecessary for the operator to give it any special attention. It is composed of a group of wattmeter elements, one for each generator, similar to the well-known Kelvin balance. These balances are mounted on a slate panel, one above the other, and the moving elements are mechanically connected by means of a fine ligament passing from one element to the other. As the indication of the wattmeter is obtained by the torque of the instrument calibrated against a standard spring, the total torque of the various elements may be calibrated against the standard spring. Due, however, to the multiplicity of balances and detailed mechanical arrangement, it is impossible to make these balances directly actuate a pointer; therefore the torque of these balances is relayed to a different device, which in turn actuates the pen and contact mechanism. The lowering element of this instrument carries a contact finger which by making contact with one or the other of two stationary fingers, automatically causes a small motor to operate in either direction. This motor drives a worm screw provided with a nut which passes back and forth, as the worm rotates, carrying the pen mechanism for making a permanent record on the time chart. This pen mechanism has in addition a cam follower which controls the tension on a spring connected to the lower moving element. As all the elements are mechanically connected to a ligament, any action on the lower element will have the same action on all the elements of the instrument.

The pen mechanism is interconnected with a sliding contact which passes over a uniform resistance through which a constant current is flowing, as shown in Fig. 1. This impresses a voltage on the two pilot wires which is proportional to the position of the pen mechanism and hence is proportional to the total load on the station.

The totalizing graphic instrument has six elements, making it possible to meter six separate generators, whether they are of the same voltage and in synchronism or not. In connection with this instrument a small ammeter and an adjustable slide resistance are required to maintain a constant current through the slide resistor for slight changes in the battery voltage, or to take care of the period when the battery is charging.

Relay Potentiometer

The relay potentiometer which, at the load dispatcher's office automatically balances against the voltage impressed on the pilot wires by the totalizing graphic instruments, is similar to the multi-circuit instrument located in the power station, except that it has only one Kelvin balance in place of several. From Fig. 1 it is seen that a positive pilot wire is connected from the sliding contact on the totalizing meter in the power station through the moving element of each respective relay potentiometer, to the sliding contact on the balancing resistance of the relay; while the negative pilot wire is connected to the similar end of the balancing resistance in the totalizing meter and in the relay potentiometer. The moving coils of the relay potentiometer are located in the magnetic field supplied from stationary coils, energized by a local storage battery. A constant voltage is impressed upon the balancing resistance of the relays by means of voltage regulator M,

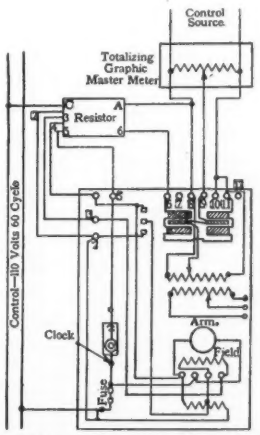


FIG. 4. CONNECTIONS FOR THE POTENTIOMETER RELAY

which maintains this voltage constant. This regulator is composed of a Kelvin balance with stationary and moving coils, its balance being adjusted so that when a current either higher or lower than the balance is set for passes through the moving coils, they will close a set of contacts similar to the motor control contacts on the totalizing instrument, and cause the small motor to drive the sliding contact in the proper direction across the three point rheostat, which is connected across the storage battery located in the load dispatcher's office. It will be readily seen that this system will maintain a constant voltage across the first slide rheostat of the various potentiometers.

The two balancing relay resistances in each circuit, together with the pilot wires, form a potentiometer whose characteristics are such that no current will flow in the pilot wires as long as the sliding contacts occupy homologous positions. Any difference in position of the two sliding contacts will, however, cause current to flow through the pilot wires and hence through the moving coil of the relay. In order to obtain a clear understanding of this action, assume that the totalizing meter in station No. 1 has a certain reading and that the

corresponding relay No. 1 stands at zero. The difference in potential between the positive point of the totalizing graphic meter and the positive point of the relay will cause current to flow through the moving coil of the relay which will close the motor contacts. This will automatically shift the contact and pointer in the proper direction to restore a condition of balance. When the current flowing through the pilot wires is restored to zero the motor contacts will open, leaving the two instruments indicating the same value of power.

Indicating Instruments

In addition to the balancing resistance, each relay is equipped with a second slide resistor through which a constant current is passed. The sliding contact of this second slide resistor is mechanically connected to the sliding contact of the first slide resistor so that the two moving contacts operate in synchronism, thus producing a variable voltage between the moving contact and the stationary contact extension. Lead wires are connected to the moving contact in order to extend the connection to the indicating voltmeters, which are calibrated in actual load values as transmitted by the totalizing graphic instrument located in the power station.

The dispatcher's indicating instruments are standard 3-in. direct-current voltmeters with scales calibrated to indicate the power according to the voltage impressed on the instrument. These instruments are located over the load dispatcher's operating desk, so that the dispatcher is able to determine the load on any individual station or on the entire system. The sixth meter in this group is a totalizing meter, operated by connecting the moving contact of the auxiliary slide resistor of each potentiometer to the stationary contact of the auxiliary slide resistor of the potentiometer adjacent to it. Instrument No. 3 in Fig. 1 is not connected into this system as this instrument indicates the load on a substation. Thus the total voltage impressed across the totalizing voltmeter is in proportion to the total load of the system and as a result this instrument indicates the total power supplied by the entire system of power stations.—The Electrical Journal.

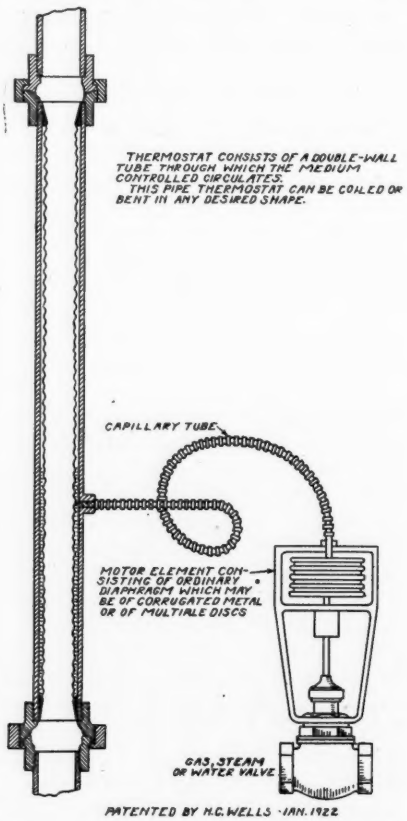
A New Form of Temperature Regulator

Novel Form of Thermostat Consists of a Double-wall Tube Through Which Medium Controlled Circulates. By Clement Wells

THE importance of heat control in industrial processes is widely recognized. New applications and new forms of apparatus to meet them are continually arising. The field divides itself roughly into high and low temperature applications, the former taking care of work such as heat treating metal processes, etc., and the latter the control of liquid or gaseous cooling and heating mediums, water, steam and gas. Within this field a new design of thermostat has been brought out, which promises special applicability for certain conditions.

At present tubular thermostats are used similar to the bulb of a distance thermometer. This tubular thermostat is commonly inserted in the heater, tank or receptacle, the temperature of which is controlled. Frequently, however, it happens that there is no room for the thermostat in this location and it is necessary to insert it in an outside pipe or a special chamber. This has certain obvious disadvantages. For instance, it involves extra expense in installation and the pipe or chamber tends to form a pocket, hindering the flow of the liquid which in turn may result in irregularity of control.

A consideration of the problem involved and the existing methods has suggested the use of pipe thermostats as illustrated. Thermostats of this kind consist of a two-wall pipe, the expansion medium, whether a sensitive oil or a volatile fluid such as ether, being located between the two walls. In this construction, not only is the controlled liquid allowed a free passage, but the sensitiveness of the regulator can be greatly


THERMOSTAT CONSISTS OF A DOUBLE-WALL TUBE THROUGH WHICH THE MEDIUM CONTROLLED CIRCULATES. THIS PIPE THERMOSTAT CAN BE COILED OR BENT IN ANY DESIRED SHAPE.
CAPILLARY TUBE
MOTOR ELEMENT CONSISTING OF ORDINARY DIAPHRAGM WHICH MAY BE OF CORRUGATED METAL OR OF MULTIPLE DISCS
GAS, STEAM OR WATER VALVE
PATENTED BY H.C. WELLS · JAN. 1922

SECTIONAL VIEW OF PIPE THERMOSTAT

increased. This latter point will be appreciated if one takes into account that an ordinary thermostat tube or bulb has a certain definite proportion of heat interchanging surface for a given content of the expansion medium it contains, but as it is feasible to extend considerably the length of a pipe thermostat and its two walls can be so close together as to take between them little more than a film of liquid or a layer of gas, the ratio of heat interchanging surface to volume of expansion medium is indefinitely increased. This results in a nearly instantaneous heat interchange and reaction. The lengthening of the pipe thermostat involves no particular constructional difficulties, as it can be coiled, bent or otherwise deformed and, in fact, may form a

part of the regular conduit used to convey the medium controlled.

Many applications suggest themselves. For instance, a Sims heater can be equipped with a pipe thermostat simply by substituting it for the exit pipe. Another application is in connection with the temperature control of the cooling water systems of air compressors and of gas and oil engines. The pipe thermostat takes the place of the discharge pipe and occupies practically the same space as the pipe now used. With gas-fired boilers, the pipe thermostat would be placed in the return circulation pipe and control the gas supply direct. The construction of the thermostat in the form of an open pipe instead of a closed tube has other advantages, where the temperature of corrosive gas or liquids is controlled, as the inner wall can be of some acid-resisting material and the use of internal joints and solder entirely avoided.

Without impairing the useful field of the tubular thermostat for ordinary tank control, etc., the pipe thermostat appears to offer decided advantages in numerous applications.

Draining the Heating System

SPECIAL PIPING EMPLOYED IN PLANTS IN SERVICE DAYTIMES ONLY; PRECAUTIONS IN THAWING FROZEN PIPE LINES. BY H. A. JAHNKE

IN MANY steam and manufacturing plants there is no night watchman nor fireman to keep up steam during the night for the heating system and in some of these plants the heating system is in use only during the day while the steam is shut off nights after shutting down time, and turned on again the next morning.

Where this system exists and the piping layout is not so arranged as to drain thoroughly at night after the steam is shut off, there will be no end of trouble with frozen pipes the next morning.

In such a plant some years ago, I had much trouble at first with frozen pipes until I rebuilt the piping layout and made changes where necessary so that each pipe line and heating apparatus would drain thoroughly of all condensation after the steam was shut off at night, also making it nearly impossible for any steam or condensation to leak into the pipes during the night should any of the valves leak or not be closed tight.

The plant consisted of one boiler and Corliss engine, two feed pumps, etc. Exhaust steam was used for heating the factory; frequently the plant would shut down when live steam was used. The exhaust pipe from the engine passed through one of the engine room walls in the factory, as shown in Fig. 1. Frequently the main exhaust pipe between the engine room wall and first branch for feeding one of the coils in the factory was frozen. After this happened a few times, I placed the drain pipe and valve B. After this valve A was closed and drain valve B opened, there was no further trouble with the pipe freezing. When live steam is used, valve E is closed.

Some readers may be under the impression that the valve A and drain valve B were an unnecessary expense, but to show that it was money well spent I relate the following: A short time before the valve A and drain valve B were installed, the engine throttle leaked badly by not being closed tight, causing a little steam to leak by, just enough so it reached the first coil on the exhaust line in the factory where the steam condensed quickly, freezing up part of the coils and the pipes C and D up to where it goes into the engine room. Next morning it took much time and loss of production before the pipe was thawed out and a number of pipes and fittings that were broken replaced.

One night while live steam was used in the heating system the helper did not close the live steam valve F tight. The results were the same as when the engine throttle leaked; steam and condensation leaked into the pipes and froze.

DRAINING THE RADIATOR AT NIGHT

THERE WERE a number of radiators in the plant and office. One morning I was told that some of the radiators in the office were not operating. After examining them I found that they were frozen, due to the condensation remaining in them over night. After disconnecting the radiator trap I found that this had remained in a closed position due to the fact that the expanding member was worn out, hence would not open. Placing a new expanding member in the trap cured this trouble. Type of expanding member is shown in Fig. 3.

After that I tried to find a way to make sure that all radiators were drained at night, regardless of whether the radiator traps were open or not, due to

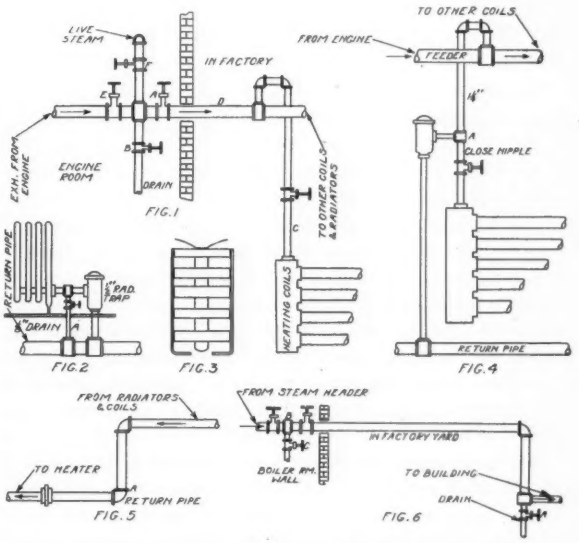


FIG. 1. EXHAUST PIPE CONNECTION TO RADIATORS
FIG. 2. RADIATOR CONNECTION
FIG. 3. TYPE OF EXPANDING MEMBER IN RADIATOR TRAP
FIG. 4. RADIATOR TRAP USED TO DRAIN RADIATOR CONNECTION
FIG. 5. LOCATION OF POCKET IN RETURN LINE
FIG. 6. METHOD OF DRAINING PIPE THROUGH FACTORY YARD

being out of order for some reason. After some thinking I hit upon the idea of placing a ½ by ½ by ⅛-in. tee between the radiators and traps, then placing a short nipple in the ⅛-in. outlet next a ⅛-in. globe valve and connecting the outlet from the valve into the return pipe as shown in Fig. 2 at A. I then gave orders to one of the employes that shortly before quitting time he must open all the ⅛-in. valves of each radiator in the plant and office; thus I was sure that there would remain no condensation in any of the radiators during the night, as, should any of the traps be closed, the radiators would drain through the ⅛-in. outlet.

Clearing Pipe of Condensation

There were two or three coils in some of the rooms in the factory. During mild weather, one or more of the coils were shut off and frequently the employes forgot to open the valves on the coils again at night when the condensation in the pipe between the valve and feeder pipe would freeze, hence there would be trouble the next morning with having not sufficient heat in the room until the pipe was thawed out and perhaps replacing broken pipes and fittings. I placed a 1¼ by 1¼ by ½-in. tee in the vertical pipe as close as was possible to the valve as shown in Fig. 4 at A, then connected a trap to the ½-in. outlet of the tee as shown. The outlet from the trap was connected into the return pipe. In this way the pipe was always clear of condensation regardless of whether the coil was in use or not, also whether the steam valve was open or closed at night.

Pocket in Steam Line Caused Much Trouble

To show that much trouble and expense may be caused where a pocket is formed in a steam line in some part of a heating system which is in use only during the daytime, I relate the following. One morning after I had the plant in operation for a short time and all seemed to be in good order, I was notified that in a certain part of the building there was no steam in the coils and radiators. At first I thought there was not sufficient pressure in the system to carry the steam to that part of the factory where there was no steam, but when examining the back pressure gage on the heater I noticed that there was sufficient pressure to carry the steam to any part of the factory, so decided that the trouble was somewhere else.

When looking for the cause I found that some of the men had thrown a pile of lumber on a long section of 2-in. pipe that fed a number of heating coils and radiators. This lumber sagged the pipe to such an extent that a pocket was formed. Of course the pipe did not freeze during the day when there was pressure in the system which kept most of the condensation that collected in the pocket moving; but at night when the steam was shut off, what condensation remained in the pocket froze. Before it was noticed, much more of the pipe line had frozen, due to the fact that the condensation could not pass through and of course as it collected it froze in the line. It took much time and labor to get this part of the system in working order again. After this experience I tacked up a notice near the pipe line that no lumber or any other material must be thrown on any of the pipe lines under penalty of being discharged. This had the desired results, as I had no further trouble with frozen pipes due to a pocket being formed by some material being thrown on them.

In a heating system that is in use only during the day and there is danger of the pipes freezing, great care must be taken when installing the system that no pockets are formed in any of the pipe lines; also that no pockets are formed after the system is in service, due to the fact that some pipe support or hanger lets go, causing a pipe to sag, forming a pocket. Where the heating system is in service continuously night and day there is no danger of the pipes freezing from this cause, but the system will not operate satisfactorily and there will be more or less noise.

Pocket in the Return Pipe

One of the return pipes from the steam coils and radiators from one part of the factory was arranged as shown in Fig. 5. At first when taking charge of the plant I often had trouble with the vertical pipe freezing at the point A at the elbow. After this occurred a few times I decided to find what caused this trouble when I found that there was a pocket at the elbow and union and at times when the returns contained much condensation some of it would remain in this pocket when the steam was shut off at night and freeze, and the next morning no condensation could pass through. As the pipe was ice cold, more of the incoming condensation would freeze before it was noticed that the pipe was frozen. All that was necessary was to shorten the vertical pipe between the two elbows so as to give the lower pipe more pitch which removed the pocket at point A.

Blowing the Pipe Clear of Condensation

In another plant where live steam for heating was furnished to a building during the day only, the building was located some distance from the power plant and the 2-in. pipe ran through the factory yard. To clear the pipe of all condensation, it was thoroughly blown out each night just before shutting off the steam on the line, which was done in the following way: The steam was shut off on the line in the boiler room, then immediately after the drain valve A in Fig. 6 at the other end of the line was opened wide, when all steam and condensation was blown out of the pipe. All went well until one night the valve in the boiler room was not closed tight or it started to leak badly, causing nearly the entire pipe line out of doors to freeze. This occurred a number of times until someone thought of arranging the pipe as follows: A tee was placed next to the valve near the main steam header in the boiler room as shown at B in Fig. 6. Another valve was placed on the other end of the tee and a drain valve in the center outlet of the tee. Thereafter the twin valves on the line were closed and the drain valve A on the other end opened, also the drain valve C between the two valves in the boiler room opened.

In this way it was impossible for any steam or condensation to get into the pipe line out of doors, as, should any steam leak by the valve next to the steam header, the condensate runs out through the drain pipe between the two valves while the other valve prevents any steam from entering the pipe line should the main valve leak badly. After this there was no further trouble with a frozen pipe.

Thawing Out Frozen Pipe Lines

There is a wrong and right way in thawing out frozen steam and water pipes. Some men when about

to thaw out pipes start at any point that may be most convenient without realizing that ice has much expanding power when heat is applied to it. For this reason it is always best to start near an outlet of the pipe line or apparatus. In this way there is not as much danger of cracked pipes and fittings as where there is no opening for the melting ice and water to run out of when heat is applied to the pipe.

If possible, disconnect some union or flange or any other fitting which may be located near the point where the pipe is frozen. Frequently I have cut pipes that were frozen and no fitting anywhere that could be disconnected to get an opening. I have found that this is much cheaper; less labor and time is wasted than where an attempt is made to thaw out the pipe without an opening near the frozen point with the result that perhaps a number of pipes and fittings are cracked which must be replaced, whereas if the pipe is cut to provide an opening with the possibility of having no cracked pipes, all that is necessary is to disconnect two joints as the case may be, then shorten one of the pipes sufficiently and thread both ends of the pipes so that they can be connected together again with a union or flange.

At the above-mentioned plant there were about 500 to 600 ft. of 2½-in. pipe which were located out of doors and furnished steam from the power plant to a nearby building for heating purposes. One morning I was told that there was no steam at the distant building. In looking for the trouble I found that the entire pipe that was located out of doors was frozen, due to the fact that the valve at the power plant on this line had not been closed tight the night before, hence a little steam leaked by with the above stated results. As I had no way of applying heat to the pipe in the position it was, I quickly had the entire pipe line, length by length, disconnected from the building to the power plant, then taken to the boiler room one length at a time, then applying steam to the length of pipe with a steam hose, starting at one end of the pipe. In this way all the pipes were thawed out in a short time and there was not a broken pipe or fitting.

Lubrication of the Uniflow Engine*

Uniflow Engine Presents Lubricating Problems Uncommon to the Counterflow Type

THE SAME GENERAL principles which are applicable to bearings and slides of other types of equipment hold for the uniflow and in a discussion of this subject should be given complete consideration.

Where units are placed so that air circulation is bad and atmospheric temperatures above normal, an oil must be selected which has a viscosity at test temperatures proportionally higher than would normally be used, so that at working temperatures the lubricant will maintain the same viscosity and fluid friction as would be proper under normal conditions.

Generally speaking, the larger the clearances per unit of diameter beyond the practical minimum, the more viscous must be the lubricant required for the maintenance of an unbroken oil film.

With perfect lubrication where only fluid friction exists, the bearing parts do not touch the journals or slides, being completely separated by the oil film. In this case the frictional losses are directly due to the internal friction of the lubricant and are entirely independent of the bearing metal and its finish. With solid friction, the loss is greatly dependent upon the smoothness and metal composition of the surfaces. As contingencies may arise which bring the bearings under the laws of semi-lubrication or even solid friction, a high finish and the proper selection of the metals is highly desirable.

In considering the practice of applying the lubricant and particularly in the case of oils which are returned to the bearings, it should be borne in mind that when there is no contamination with lighter blending liquids, the lubricant increases in viscosity with use. The oil in any system should be renewed when it becomes evident through increased frictional temperatures that it is becoming unfit for use on account of increased viscosity or a gradual breaking down.

In bearing design, pressures are of first consideration. At equal speeds for the same bearing metals and identical surface conditions, the greater the pressure per unit of area, the heavier the oil must be successfully to resist being squeezed from the bearing. For strictly fluid friction, which of course we seek to attain, under ordinary pressures the frictional resistance is practically independent of the pressure between the surfaces. Heavier pressures require more viscous oils, and fluid friction increases with viscosity.

The question of speed is most important in discussing the selection of the bearing lubricant. The higher the speed of the bearing, the higher the pressure which will be built up in the oil film and consequent resistance to breaking of the film. This increased pressure is due to the pumping action aided by the adhesiveness of the lubricant to the bearing surfaces. This means that as speeds increase oils of less viscosity can be used and still have no metallic contact. Lubricants should be introduced into the bearings at the point of minimum bearing pressure.

Friction losses vary greatly with the method of application. Stream lubrication with positive feed, adequate oil supply, and efficient oil purification, in which it is possible to keep the system free from leaks and other major losses, are recommended above all other methods. If all these features are not present the system, generally speaking, will show some loss of effectiveness in its lubrication. With satisfactory stream lubrication, the main advantages to be expected are: Longer life of bearings due to small or no solid friction, possibility of using oil of lowest viscosity, increased life of oil through decreased abuse and lower oil temperatures, decreased vibration thereby lessening depreciation, and a saving in the labor of attention. Individual systems are satisfactory if the oil supply is copious and a means of continually cleaning the oil is provided. Ring oiling is definite enough, but lacks the oil cleaning feature.

*Abstract of an article appearing in Lubrication, which is published by the Texas Company.

The prime virtue of the splash system lies in its simplicity, but the fact that the supply is not positive and the lubricant unpurified is claimed to detract from its value. Hand feed and drip cups require heavier oils, also maximum labor of attention. They make the oil supply uncertain, are wasteful of oil and lack the advantages gained where a copious oil supply would carry away the frictional heat of the bearings.

Selection of Engine Oil

Specific recommendations to cover the whole field of uniflow engines obviously cannot be made; but in general it can be said that the first consideration is that the oil must be well refined and of the proper viscosity. For hand and drip feeds, oils of 300 to 500 sec. Saybolt viscosity at 100 deg. F. are found satisfactory. For steam lubrication, oils having a viscosity of 150 to 200 sec. Saybolt at 100 deg. F. should serve well. The oil should be particularly free from emulsifying tendencies if the presence of water in the oil is a possibility. Specifications of flash point and fire point are absolutely worthless in measuring lubricating value. Pour test specifications are very rarely of value in this service as the oils are seldom exposed to very low temperatures. Gravity may indicate to a slight degree the ability of the oil to separate from water but when considering this action the emulsion test results are more important by far than the gravity indication.

For other methods of application, the selection of the proper lubricant will be dependent upon the varying conditions of design and operation but the specifications will lie between the extremes named in the above paragraph.

The Uniflow Valves and Cylinders

In analyzing uniflow engine cylinder lubrication there are factors which deserve our attention as being uncommon and generally non-existent in the counterflow. These factors involve length of cylinder, weight of piston, steam conditions, piston clearances and bearing pressures, steam jacketing, oil distribution, results of excessive consumption, rod and packing lubrication. The cylinders of uniflow engines are longer than those of the counterflow of the same stroke. This is due to the fact that the piston is only shorter than the stroke by the amount of travel necessary to uncover the exhaust ports at the end of the stroke. The unusual length of the cylinder gives increased areas wiped by the piston, thus demanding an oil that spreads consistently and well. This also results in increased oil consumption over that of the counterflow of equal bore and stroke, operating under identical steam conditions.

The increased length of the piston as described in the preceding paragraph brings attention to its increased weight, which is considerable in spite of designs to make it a minimum. The usual uniflow piston incorporates from four to six piston rings. Ordinarily, in the smaller sizes, the piston rides on the cylinder walls, which design gives a bearing pressure of 4 to 6 lb. per sq. in. of projected area. This, of course, does not produce a difficult condition to lubricate. If, however, a contingency should arise whereby the weight of the piston is carried on the rings, the pressure between the rings and cylinder walls increases abnormally. This produces a difficult condition to lubricate inasmuch as the metals used in manufacture do not permit of high running bearing pressures. Theoretically, trouble will be experienced when this pressure exceeds 100 pounds per square inch with a piston surface speed of 200 ft. per min. and when using an oil which is ordinarily of proper grade. With lower speeds, there will be trouble before this pressure is reached.

Considering the selection of the oil from the standpoint of steam pressures, temperatures and quality, it will be noted that a heavier oil, with compounding, will have to be selected for the uniflow than for the counterrflow operating with similar steam conditions. The increased viscosity is necessary since continued high temperatures prevail in the uniflow at the ends of the cylinder, while corresponding parts of the counterflow are cooled by the washing of the exhaust steam. As the expanded steam passes out of the center in the uniflow and all of the expansion takes place in one cylinder, the cylinder walls at the middle of the cylinder are continually washed by the wet steam. This necessitates sufficient compounding to satisfy this condition in order to get proper lubrication, but the compounding should be kept at a minimum consistent with good practice for two reasons: First: when the animal oil used for compounding is exposed to the high temperatures at the ends of the cylinder, there is a tendency to form acids through decomposition, and there is a possibility of the acids attacking the cylinder wall finish. Second: where the condensate is returned to the boilers or used for ice making or in a heating system, the difficulty of oil separation from the exhaust steam is proportionately increased with increase of compounding percentages. There is, therefore, a correct amount of compounding suitable for each operating condition, but in general this amount does not exceed 8 per cent for the best lubricating results, even with a larger percentage of moisture in the throttle steam. Due to the maintained high temperature in parts of the cylinder there exists a condition conducive to carbonization of excessive or poorly refined oil so that the ability of the oil to withstand carbonization at the working temperatures must be well considered in selecting the oil.

As previously stated, to maintain high temperatures at the admission ends, these parts are steam jacketed, the general practice being to use throttle steam, the steam passing from the jackets through the valves to the cylinder. This causes a condition which makes it impractical to introduce the oil into the steam line by atomization methods as the jackets act as separators, removing the oil in varying degrees from the steam before it gets to the cylinder. It therefore becomes necessary to introduce the oil directly into the cylinder, depending upon the piston to smear the oil over the cylinder walls, the extent of smearing, of course, depending upon the number and location of the points of introduction of the oil. This condition makes the use of a heavy oil necessary, especially if the number of feeds is small.

In considering the proper number and location of the points of introduction of the oil to the cylinder, it may be said that while these will vary with different installations, that plan whereby the distribution of the oil is most efficient is the best. The minimum number of distribution points is obtained with only two feeds,

one at each end at the top of the cylinder. Distribution efficiency, however, will increase with the increase in the number of feeds, and improved results can be obtained by locating these top feeds near the central exhaust belt. Increased number of feeds does not necessarily mean increased overall consumption. On the other hand, it should mean decreased consumption as a result of better distribution. Satisfactory lubrication should be secured on any unit with six cylinder feeds, one at each mid stroke position at the top of the cylinder with the others lying below them in the same vertical plane at a point from 90 deg. to 120 deg. from the top. Feeding cylinder oil to the walls through the piston and piston rod is a method suggested but not yet adopted. This should give satisfaction if properly developed.

Again, due to the high temperatures maintained at the ends of the cylinder, conditions are conducive to carbonization of the oil remaining on these parts for extended periods. Increased carbon deposits can therefore be expected with excessive increases in oil consumption. Consumption in the uniflow should therefore be limited to the minimum even more closely than in the counterflow where the cylinder walls are alternately heated and cooled.

A separate feed receiving the necessary attention to insure constant supply should be fitted for the piston rod and rod packing at the stuffing box, as it is possible to get unusual running conditions here by unequal expansion, particularly so in the units operating without tailrods. Where crankcase splash is used and bulkheads are fitted with stuffing boxes, the same oil as is used in the crankcase should be used in the bulkhead stuffing boxes. The use of cylinder oil in this box should be avoided, particularly when compounded cylinder oils are used, as the compounding aids in forming emulsions in the crankcase oil.

Selection of Cylinder Oil

In the selection of the proper grade of cylinder oil, viscosity should be considered first. The fact that the piston is out of sight and the action takes place under higher temperature conditions, does not eliminate the application of the law which states that an oil should be used which gives practical and efficient lubrication with the lowest viscosity. In the light of conditions as described above and from experience, it is found that a medium bodied cylinder oil of 125 to 135 sec. Saybolt Universal Viscosity at 210 deg. F. is well suited for most units using dry saturated, throttle steam up to approximately 125 lb., while for pressure and temperatures above this, an oil of 150 to 160 sec. Saybolt Universal Viscosity at 210 deg. F. has been found to be well adapted. Unless compounding in the oil is found objectionable from the standpoint of goods manufactured or the use of the exhaust steam for other than manufacturing purposes, an oil is advised with some compounding, but not to exceed 8 per cent.

Conclusions

Naturally there is much to be added to the above relative to the special devices incorporated in the design of the individual manufacturers, but since this article aims to discuss the general lubrication of the uniflow, the discussion of special lubrication has been omitted. Where problems arise in connection with the lubrication of special devices, the designer or operator should request the co-operation of some reputable lubricating engineering staff which has had broad experience in lubricating matters.

Trouble Hunting---XVIII

Getting Boilers Into Working Condition. By John Pierce

THE OLD BOILERS being crowded beyond their capacity, I went to the trouble of insisting that my two superintendents get together and order a new set, in fact two sets, of boilers, and I put the facts to them in such a way that they could not further ignore my request. Then began a great scramble for list prices, catalogs, and everything pertaining to the purchase of such things. My recommendation was any standard make of boiler, either water tube or tubular. I wanted boilers, and I wanted good boilers. They both agreed that we not only needed them, but that we should get them at once.

We finally learned, through our purchasing agent, that we could get "war boilers" at Beaumont, Texas. These were supposed to have been boilers that were built during the big war especially for the government, and held by the U. S. Shipping Board for sale. After a few preliminary skirmishes, we found that some hundreds of boilers had been bought by a firm in the East—Chicago, I think—and that they had sent a large number of Heine, Babcock & Wilcox, Erie City, Frost, and several other makes to various distributing points around over the United States, and were selling them to whoever would buy, and shipping from their nearest point. Among the many other makes were some designated as "Standard Marine Water Tube Boilers."

Our purchasing agent got busy, gathered up all the various data, plans, and blueprints he could secure and sent them to us for inspection and advice. We were somewhat delayed because the blueprints and plans were not those of boilers at all, but were for the construction of wooden ships. Perhaps he was of the opinion that having so much water in the mine, we needed ships. We returned this batch of prints and received next the specifications of the various boilers. At this point I made bold to say that I didn't give a "tinker's dam" for the prints; what I wanted was boilers, boilers good for 200 lb. pressure, and capable of giving at the least, without crowding or forcing, 250 hp. of steam, each. They showed me the specifications of the "Standard Marine Water Tube" and I decided then and there that we did not want them. In the first place, they were 14 ft. wide and only 6 ft. long. They were steel enclosed and were hard to do anything with. They had only 3-in. flues, and were only "three pass" boilers, giving the hot gases a travel of 18 ft. They were in every way unfit for our service and I told them so, and why. But these were the boilers purchased.

While waiting for the boilers to come, I decided to build a permanent fuel oil tank and get things lined up for them. We learned that they had left Beaumont, Texas, and had reached the border. We paid for them $5000 each, net f.o.b. cars. There were only two of them purchased, and while I grumbled at this, I thought it much better than none at all; but I predicted what would happen to them in no time at all. When they reached the border, we were informed by the Mexican railways that we must pay the duties, counselors' fees, etc., as well as the freight, before proceeding with them. One of our own locomotives had been sent to the border with our own paid crews and caboose, and naturally we were surprised to find it would cost us 11,000 pesos—$5500—to get them to their destination. Think of it! Only $10,000 worth of boilers, and such a tax as this; we to do our own hauling. But we paid it, and ordered them forward. It was nearly three weeks before they came.

While waiting, we built a dandy two-compartment stone tank for fuel oil; got it all piped up and everything looking fine. I was very proud of that tank. It had very heavy walls, and looked as if it would stand there hundreds of years, a monument to my memory. After it had thoroughly set, and was in the proper shape, we put a wall of cement on the inside of it, and a 6-in. cement floor, filled it with oil, and went home happy. The next day after filling it I took some friends to see my wonderful stone tank, and all remarked on its being built so heavily. So we went home happy the second time. The following morning, however, as I was riding my horse up the mountain road I met a stream of oil half a mile below the works. Well, I knew right now that some terrible thing had happened to my beloved tank. I rode on some little distance until I came to the place where my horse refused to wade into it and I had to get off and walk the rest of the way.

Arriving at the works I found the worst mess I'd ever seen in all my life. Oil was thrown on the buildings, on the roof, and all over the place. We sent at once for the watchmen who had been on duty near the tanks. The watchmen by this time had gone home, had made no report at all to any of us regarding it. After we had called them to my office for an investigation, they said they had heard a roar and started around the building to see what it was and met the oil coming. Further than this it was impossible to learn. They merely shrugged their shoulders and said, "quien sabe" (who knows). We were at no loss to know what had happened, for there were the long burned fuses that had set off the dynamite which sent her up. Well, Uncle John did some tall cursing but cursing would do no good. The tank was ruined, and that was all there was to it, so, as we simply had to have oil, I cleared away a place and built another.

This one was built differently. I made it a two-compartment tank, each side holding 10,000 gal., and she was 10 ft. deep when finished. But her walls were 48 in. thick at the bottom and 36 in. thick at the top, sloping in from the outside. The floor was 20 in. thick except directly under the walls, where it was 36 in., and all resting on rock. In the construction of this tank, I used 40,000 lb. of steel rails, the small rails that are used in mine work. The ends were bent and all hooked and interlaced with each other. In addition to these rails, I threw in, haphazard, 5 T. of bolts, rods, and other pieces of metal. I certainly was giving nobody a chance to blow up and damage this tank beyond repair.

By that time I had men at work getting as many pieces of the big hoist from the junk heap as we could so that we might assemble the hoist and get ready to "boil" water as well as pump it with the air lift. Now, if the gentle reader will remember, I wrote in one of my previous articles regarding these hoists, saying that the three of them were apparently the same, having only a few thirty-seconds difference between their respective parts and that of their neighbors. Imagine then the fond feeling for the world in general and rebels especially, when, after hauling and pulling and prying, we would finally get a piece out, get it all cleaned and scraped and ready to go onto the next piece, to find that it belonged to one of the two that we didn't want to use. "Woe is me." I certainly felt as if I had rather be any place else than there. Did any of you fellows ever see the disk of a 500-hp. hoist? Or the crank shaft? Think, then, of getting the shaft up 40 ft. in the air, working it along until she set in her pillow blocks, the disk mounted and all ready to drive the keys, to find, on lining her up, that you'd got the wrong shaft, and the one on hand was ¾ in. too long!

We finally got one hoist together, and started bolting her up when the boilers arrived. So we dropped work on the hoist and started to unload our boilers. We got them off the cars and found quite a bit of them left. The Mexicans had not stolen all the loose pieces, just those that they could get off easily. But we looked them over and started in on them. I hunted those two boilers from one end to the other, trying in every way possible to find a single inspector's mark on them to show that they had been accepted by the government and made report to my company to the effect that they were "rejected" boilers, and I would mount them only under protest. This report brought the president from New York, in person, and he fully agreed with me regarding them, but carefully explained that the stockholders had given notice that the final, or last appropriation for opening up the mine would be the last money they would advance, and the mine must either "sink or swim" with the money on hand. Seeing this was the last hope for that particular property, though the company has many others, I decided to go ahead.

Well, we set them up and looked them over. Of all the poor workmanship and miserable construction that man ever saw, it was in those Standard Marine Water-Tube boilers. The water legs were full of steel shavings, made by cutting the tube sheets for tubes; there were bolts, nuts, pieces of tube expanders, pieces of cutter tools—cold chisels, calking tools, and just plain steel rods in them. It certainly had been an outrage to send good Americans to sea in boats which carried boilers like these. When we finally did get them steamed up, we found that half the seams leaked, and leaked badly; fully one third of the rivets leaked, the manhead did not fit the hole and days were spent in dressing it to shape to get a fit. The flange pads were riveted on with four rivets to a pad and every one was in such deplorable shape that all had to be dressed down and scraped to make them hold water at all. Every fitting on the

boiler leaked, and the gage glasses were a bastard size. Taken all in all, these boilers were an outrage. The boilers themselves were mounted on a steel casing and the casing was nothing more nor less than a huge box made of very thin material. Now imagine some 35 T. of steel boiler, water, and stack resting on this casing and a heavy oil fire beating against the 9-in. brick wall in the rear. If one made it any thicker he simply ruined his fire space, for he had but 6 ft. to start with, and every inch less that he made it was that much worse. Dutch ovens to give longer space for the flame could not be constructed as the front of this miserable casing carried the water leg of this boiler front, and there was absolutely no way possible to remove it and carry the weight of the leg. There were no ports, nor pillars of steel to act as a support in case Dutch ovens were considered, and we had to cast about for some way to get the most of one bad bargain.

Psychology of the Power Plant

PSYCHOLOGY and boiler stoking are two things that would hardly be considered as capable of being closely connected, yet an experience which has recently come to the attention of the writer would appear to prove that gratifying and important results can be gained by applying psychological principles to improvement of conditions in a power plant. The experience occurred in a large New England factory. While the methods employed by the master mechanic of the plant extend to all departments under his supervision, the limits of this article compel restriction of the present narrative to an account of progress and success in the boiler room. The master mechanic, who for short, may be called the executive, is essentially "a progressive party." He cannot be kept tied to the hitching post of "things as they are." He holds the belief that new industrial conditions demand new methods and new men, so in practice he adopts the new methods and selects or shapes the new men to carry them out. In the boiler room, when he took charge, there was a force of men, good in their way, but wholly unprogressive and incapable of adapting themselves to new ways. Some had spent many years in the service of the corporation and the management was laudably reluctant to disturb them. In this reluctance as well as in real sympathy for the men, the new executive shared. Finding, however, that substantial advance in efficient operation could not be made without a change, he held conference with the agent of the mill, with the result that all restraint on his action was removed.

Just here psychology lends a hand to smooth out difficulties. Instead of arbitrarily using his power to discharge the men, the executive conferred with them; explained the situation to them and informed them that it would be necessary to replace the entire crew with new men. But, he told them that no man would be discharged or be obliged to lose a meal on account of the change. They would be allowed ample time to find and would be aided in obtaining employment in other parts of the factory or elsewhere as they preferred. In this way, without friction or ill-feeling, the way was prepared for the next step in advance.

The next move was to secure men with sufficient education and ambition to appreciate and utilize opportunities for advancement. This having been accomplished, plans were formulated to afford the means of acquiring technical knowledge and stimulating a desire to make the most of it. A school was formed among the men and competent instruction secured. As a result of the procedure, the efficiency of the force was greatly increased and boiler room expenses greatly diminished. It may be noted as indicating the appreciation by the company officials of the good work accomplished by the school that one of them meets from his own resources all expenses of the school work. But not less notable and important than the efficiency attained is the spirit of good will and accord between the men themselves and between them and the management. Every man is not only permitted but specifically invited to see the executive and is assured of a sympathetic hearing and satisfactory adjustment in any case that portends trouble. In practice it is found that but few cases arise, and that even in these few a good talk usually straightens things out. The executive holds that any serious quarrel or disagreement among the men would lower to some extent their team work efficiency, so he is alert to prevent trouble or remove it should it occur. He takes a deep personal interest in the men and does not hesitate to show it. A standing exhortation of his is: "I want each man to try for the job above him. I would be glad to see any of you in a position to give orders instead of receiving them. The higher you go the better I will like it. All the men now in higher positions including myself must some day go and the most competent will be the ones to fill the vacated places."

Men who have secured licenses through their experience in the plant and the instruction given in its school have been hired by other concerns, and it is characteristic of the psychology prevailing that gratification at the advancement of the fortunate ones rather than selfish regret at the loss of their improved ability is the sentiment expressed by "The Boss."

The concrete lesson to be drawn from the experience in this power plant seems to be that the warm hearted psychologist, rather than the coldly mechanical efficiency expert gets the best results where the human element is a factor, and that by a sound psychology, whether consciously or unconsciously applied, the willing co-operation of the men and the cordial support of the management may be secured.

IN AN ANNOUNCEMENT just issued by the Department of Commerce, through the Bureau of the Census, the manufacturing establishments covered by the census of 1919 are classified according to the number of wage-earners employed in each establishment. Out of a total of 290,105 manufacturing establishments 141,742, or 48.9 per cent, employed only from 1 to 5 wage-earners; 56,208, or 19.4 per cent, employed from 6 to 20; 25,379, or 8.7 per cent, from 21 to 50; 12,405, or 4.3 per cent, from 51 to 100; 10,067, or 3.5 per cent, from 101 to 250; 3600, or 1.2 per cent, from 251 to 500; 1749 or 0.6 per cent, from 501 to 1000; and 1021, or 0.4 per cent, employed over 1000 wage-earners each. There were 37,934 small establishments which reported no wage-earners, the proprietors presumably doing the work themselves. The census, however, is not supposed to include all small establishments but only those having an annual output of at least $500.

Alarms for the Power Plant

THE WRITER has made use of many gages that were discarded around the plant to give an alarm whenever pressures begin to fluctuate beyond that desired. They have been used on steam, water, air, ammonia, high and low pressures.

Figure 1 shows how the attachment is made to the gage. A piece of German silver wire is soldered onto the stem of the curved rack; an oblong hole is cut through the side of the gage case so that the wire can extend through the gage and meet terminal. Regulation for desired pressure can be had by adjusting the screw on the terminal which is on the outside mounted on a piece of insulating material.

If desired the terminal can be set inside of gage casing but would have to be insulated at point of attachment, this would also require taking the face of the gage off when a readjustment is desired.

Due to slight fluctuations which are present in most pressure gages a constant ringing bell is desired so if

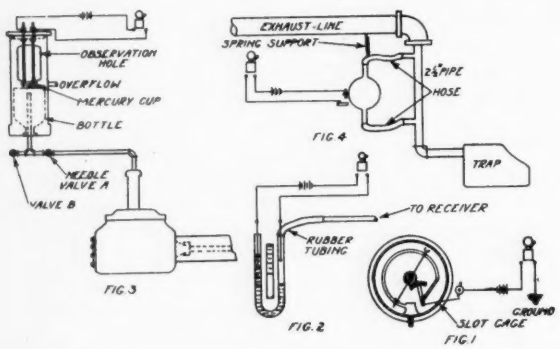


FIG. 1. GAGE FITTED WITH ELECTRICAL CONTACT
FIG. 2. ALARM CONNECTIONS TO U-TUBE PRESSURE GAGE
FIG. 3. ALARM GIVING WARNING OF AIR LEAKS IN PUMP SUCTION
FIG. 4. ALARM FOR TRAPS

connections are once made the bell will ring continuously until the operator disconnects or remedies the pressure.

Figure 2 shows how an alarm was made for a low-pressure blower. The minimum pressure was to be 1¾ in. mercury, 2 in. was generally maintained. A boiler gage glass was bent into a U-shaped form; a piece of rubber tubing was used to connect the U-gage to the piping. A wire was inserted through the atmospheric leg and into the mercury of the U-gage. The other wire was inserted through the rubber and into the pressure side leg of the U-gage to the point where the alarm was desired.

Annoyance was experienced with a pump which was drawing water from a vacuum reboiler under 25 in. vacuum. At times, leaks would develop in the stuffing-boxes of the rod, valve stems and piping. This would cause the water to become aerated and unfit for use. An alarm, as shown in Fig. 3, was decided upon.

Taking the cover off the pump, we drilled and tapped it for a 3-in. pipe connection; a piece of 3-in. pipe with cap on end made the air chamber. A ⅛-in. connection from the top of the air chamber was run to a water tank made of 4-in. pipe capped on bottom. This tank contained a bottle of about one quart capacity; the ⅛-in. pipe ran through the cap, then into the bottle, upon which was a small glass containing mercury. A small amount of water regulated by needle valve A was continuously left running, that is, about dripping.

When air was present the water in bottle would be displaced, causing it to rise; when rising, the mercury in the small glass would meet the contacts and cause an alarm. The cover on top of tank consisted of a piece of slate drilled to receive two ⅛-in. brass rods which had a small piece of German silver soldered on the ends. Valve B is used for expelling the air from the bottle after closing valve A.

A hole was cut in the side of the tank for observation, also an overflow, as shown, to take care of the drippings.

Figure 4 shows a float used to make contact and give an alarm whenever the trap failed to operate. It will be seen that if the trap failed the 2½-in. pipe would fill with water, also the float. As the water entered the float, it would descend, making contact. A hose connection is used between the pipe and float connection to give it flexibility. I have used this device on an exhaust line in connection with a vacuum trap.

AUG. GASS.

Design of Tank Tower

SOMEBODY has said (Kipling, I think) that "There are four-and-twenty ways of writing tribal lays, and every bloomin' one of 'em is right." So it is with engineering—there are numerous more or less satisfactory solutions of the problems of the day's work.

In the March 15 number of Power Plant Engineering, F. W. Brady illustrates by example the method of solving the problems attending the design of a tower for the support of an oil tank.

Without criticizing Mr. Brady's design, the following is offered as an improvement upon it. Beginning with the foundation piers, we would carry them down to 2 ft. 6 in. below grade and allow them to project 6 in. above. Instead of battering the sides of the piers, we would make them the form shown, as this requires only a

square hole in the ground for the footing course and a simple square box form for the top.

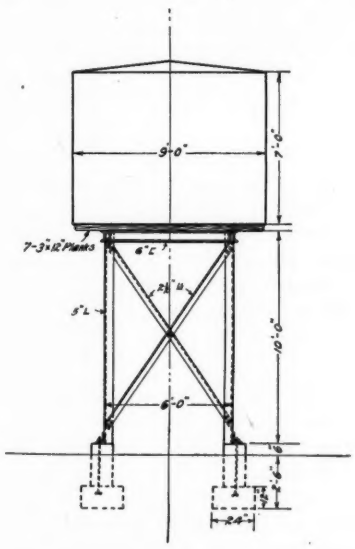
The columns, or legs, are placed 6 ft. apart, which permits the sides of the tank to project over the edge of the platform. This prevents rain water getting under the tank, which, by the way, is the cause of the deterioration of many tanks placed on floors that project beyond the sides of the tank.

In designing the columns, Mr. Brady limits himself by the consideration of the least radius of gyration. The limiting ratio usually assumed is 125. This ratio is the limiting factor only when the column is loaded to capacity as set by the formula $16{,}000 - (70 \times L \div r)$. In the columns prescribed by Mr. Brady (5 by 5 by ¾ in.) the permissible unit stress, by the foregoing formula, and assuming an unbraced length of 10 ft., is 7000 lb. per sq. in. This makes the actual stress of 800 lb. per sq. in., due to the dead load, seem ridiculous. Having the 5-in. angles on hand, however, we shall use them. A 6 by 4 by ½ by 8-in. angle for the base is ample. In lieu of this size, a 5-in. angle may be used; what is desired is two rivets connecting the angle to the column.

The bracing may be the 2½ by 2½ by ¼-in. angles which are placed diagonally as shown. (The bracing on the other sides of the tower are not shown on the drawing—this for clarity.)

For the top framing we may use 6-in. channels, or 8-in. channels should they be available and at no greater cost. We may mention here that the deflection limitation of 1/360 of the span applies to beams carrying plastered ceilings and need not be considered in this case.

The platform, or floor, is made of 3-in. planking which need not be fastened down; 3-in. planks are ample in this design because the span has been reduced to



REVISED TANK TOWER

6 ft. The ends of the planks are sawed to a circle that is 2 in. less diameter than the tank, which prevents rain water getting under the tank.

Steel structures that have been correctly designed look "skinny" to the uninitiated. In the present design the question of stability against wind pressure might be raised. Assuming a wind pressure of 20 lb. per sq. ft. over the projected area of the tank, the overturning moment is $9 \times 7 \times 20 \times 14 = 17{,}640$ ft.-lb. The resisting moment is the weight of the tank (empty), structure, and concrete piers on a moment arm of 3 ft. The weight required for stability is, therefore, $17{,}640 \div 3 = 5880$ lb., which is much less than the total weight.

It might be mentioned here that the best design for the support of this tank is a three-legged tower. The angles are readily partly closed at one end to conform with the triangular plan.

C. O. Sandstrom.

Fighting Scale

In a letter signed by James E. Noble in the March 15 issue of Power Plant Engineering, he says that "the best method of preventing scale formation in boilers is to remove scale-forming material before it enters the boilers." He also says that equipment for so doing is rather costly. Nobody can deny the correctness of either statement, and, inasmuch as the cost of this kind of equipment usually amounts to thousands of dollars, it may be questioned whether it is not out of proportion to the returns for small or moderate sized plants. Just at present the matter of undertaking such a large expenditure is being examined with a good deal of hesitation by many executives.

But all this is no reason for injecting into the boilers chemicals which are of doubtful value to say the least and the use of which is dangerous in many cases. Also, treating a boiler even with homemade remedies, as Mr. Noble suggests, at a cost of $5 to $10 a barrel, is going to run into money. In addition there is nothing certain about them. The only reason for them, it appears to me, is the desire to save the trouble that an actual, mechanical cleaning costs.

Conscientious engineers have found that they can't very well avoid this trouble if they would have certainty instead of guesswork. The sight of several hundreds of pounds of scale removed from a single boiler is quite a compensation for a day's work now and then.

Mechanical tools make boiler cleaning quite easy. I believe that any one of them is worth tons of caustic soda or sal soda which Mr. Noble suggests for the purpose. The main advantage of thoroughly cleaning the tubes is a saving of 10 to 50 per cent in the fuel consumption, not to speak of easier steaming of boilers and longer life of the tubes. Wm. Harris Day.

Collapsing Strength of Iron Pipes and Tubes

In the April 15, 1921, issue of Power Plant Engineering I noticed an article by W. F. Schaphorst on "Collapsing Strength of Iron Pipes and Tubes" which contained an alinement chart solving the formula

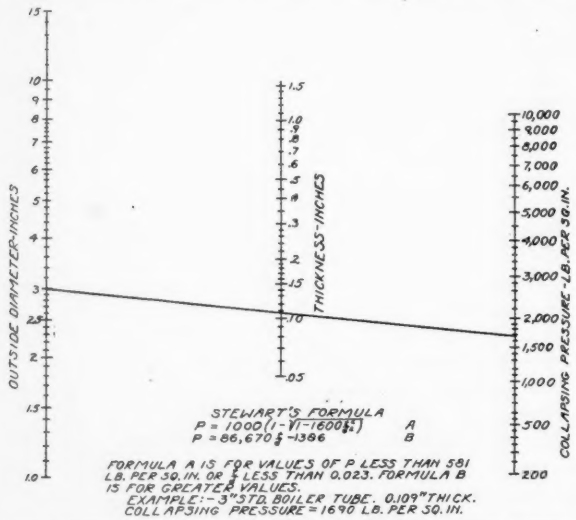
$$P = \frac{9{,}600{,}000\ t^{2.18}}{LD}$$

At that time I filed this chart away for future use. Recently I attempted to use this chart as a check in designing and discovered considerable discrepancy between the results given by this chart and tables based on Professor Stewart's experiments for the National Tube Co.

On looking up the matter in several handbooks, namely Kent, Marks, Machinery and Halsey's, I found that they all give Stewart's Formula and in addition Marks has the following to say:

"For collapsing pressure, where L is not greater than 6D, Fairbairn's empirical formula (1858) is: $P = 9{,}672{,}000\ (t^{2.19}/LD)$, or, more simply, $P = 9{,}675{,}600\ (t^2/LD)$."

In 1906 two series of experiments were made by Prof. Reid T. Stewart on Bessemer steel lap-welded tubes (see Trans. A.S.M.E., vol. 26, p. 730). In one series the tubes tested were 8⅝ in. in outside diameter and of varying thickness and length, while in the other series they were 20 ft. long and of varying thickness and diameter. The tests showed that all of the old formulas were inapplicable to the wide range of conditions found in modern practice. Prof. Stewart found that the length of tube between transverse joints tending to hold it to


OUTSIDE DIAMETER-INCHES
THICKNESS-INCHES
COLLAPSING PRESSURE-LB. PER SQ. IN.
STEWART'S FORMULA
P = 1000(1-√1-1600 t²/D²) A
P = 86,670 t/D -1386 B
FORMULA A IS FOR VALUES OF P LESS THAN 581 LB. PER SQ. IN. OR t/D LESS THAN 0.023. FORMULA B IS FOR GREATER VALUES.
EXAMPLE:-3" STD. BOILER TUBE. 0.109" THICK. COLLAPSING PRESSURE = 1690 LB. PER SQ. IN.

COLLAPSING STRENGTH OF STEEL PIPES AND TUBES WITH LENGTH GREATER THAN 6 TIMES THEIR DIAMETERS

a circular form has no practical influence upon the collapsing pressure of a commercial lap-welded steel tube, so long as this length is not less than about six diameters of tube.

As based upon his researches, Stewart's formulas for the collapsing pressure of modern lap-welded Bessemer steel tubes are as follows:

$$P = 1000\ [1 - \sqrt{(1 - 1600\ t^2/D^2)}] \qquad (a)$$

$$P = 86{,}670(t/D) - 1386 \qquad (b)$$

Formula (a) is for values of P less than 581 lb., or for values of (t/D) less than 0.023, while formula (b) is for values greater than these.

Kent gives the following extract from an article by S. E. Slocum in Engineering, January 8, 1909: "Heretofore designers have been forced to rely either upon the antiquated experiments of Fairbairn, which were known to be in error by as much as 100 per cent in many cases, or else to apply the theoretical formula of Love and others without knowing how far the assumptions on which these formulas are based are actually realized."

A single formula and curve combining both of Stewart's formulas is given in Peddles "Construction of Graphical Charts." The formula there is:

$$\frac{T}{D} = 0.00274 \times \sqrt[3]{P} + 0.000{,}000{,}001{,}1\ P^2$$

I am inclosing a print of an alinement chart based on Stewart's formulas as obtained from a table in Kent's Handbook.

It will be noticed that this chart is for lengths greater than six diameters. For lengths less than that, the chart does not hold good but is on the safe side.

DONALD J. BERGMAN.

THE EDITOR of Power Plant Engineering very kindly submitted to me a copy of Mr. Bergman's letter for any possible comments I might have to make upon its publication.

I am pleased to know that Mr. Bergman has gone into the matter of collapsing strength of iron pipes and tubes so thoroughly and has unearthed some formulas that are evidently much better than the formula on which my chart was based as published in the April 15, 1921, issue of Power Plant Engineering.

Somewhat over a year ago I had occasion to look into the collapsing strength of iron pipes, tubes and cylinders and looked through all available sources, did considerable corresponding on the subject, spoke to practical designing engineers who have had much more experience than I have had, not only with tubes subject to collapsing pressure, but with large vessels such as condensers which maintain a high vacuum within and consequently must resist an enormous pressure from without. The upshot of it all was that I considered the formula:

$$P = \frac{9{,}600{,}000\ t^{2.18}}{LD}$$

as being the most used formula of them all. It is a much quoted formula and, like Mrs. Winslow's Soothing Syrup, has been used for many years—63 yr. to be exact. On account of the exponent 2.18, however, and the large constant 9,600,000, substitutions are not as easy as in most formulas used in engineering, consequently I based my chart upon this well-known and much-used formula.

The writer did not intend to claim that the chart would meet all problems of tubes, pipes and cylinders subject to collapsing pressures. There certainly is no doubt as to the authenticity or age of the formula, but caution should be exercised in its application, just as is done, or should be done, with all formulas used in the design of engineering structures.

W. F. SCHAPHORST.

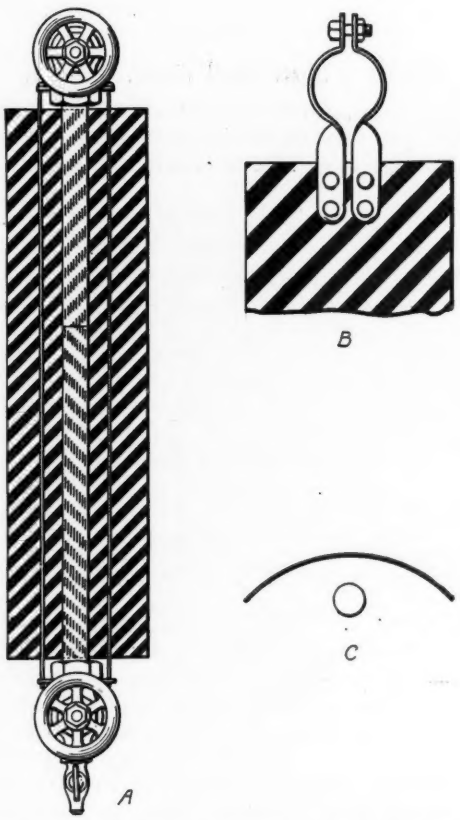
AN INVESTIGATION of the gum-forming constituents of manufactured gas will be undertaken by the Bureau of Mines in co-operation with the United Gas Improvement Co., of Philadelphia, Pa., which company will bear the expenses of the investigation. It is proposed to make a study of the nature and production of gum-forming constituents in manufactured gas which decrease the efficiency of its utilization. Dr. R. L. Brown, associate physical chemist, will direct the work, which will be performed at the Pittsburgh station and at the plant of the United Gas Improvement Co. in Philadelphia.

IDLE FOLKS indulge in useless conversation.

Safety Device for Determining Water Level in Gage Glass

IT IS difficult to determine the water level in a gage glass from a distance without straining your eyes, and sometimes then it is quite confusing. A little device can be made very cheaply which will remedy this condition.

Take an empty gage glass and half fill it with water, then place it in front of something with lines running in a diagonal direction, and you will observe that through the portion which is empty the lines will continue to run in the same direction, but those lines seen through the water will appear to run in the reverse diagonal direction.



DIAGONALLY STRIPED BACKGROUND FOR GAGE GLASSES AND DETAILS

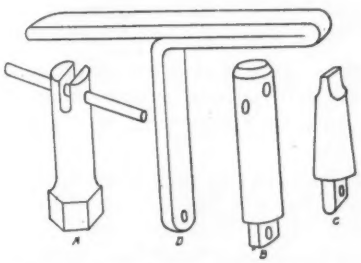
This principle may be applied as a safety device for determining the water level in a gage glass as shown in illustration by using a piece of sheet metal about 5 in. wide, the length of which must be determined by the length of the gage glass. Paint the background white, then stripe diagonally with black lines about ⅜ in. wide and about ⅜ in. apart. This piece of sheet metal should be slightly concave so that it will fit around the glass as at C so that it may be seen from any position on the floor.

A clamp for fastening the plate in place is shown at A, the detail dimensions of which must be taken from the column to which it is to be attached.

GEORGE C. STIERHOFF.

Socket Wrench Attachments

AN ENGINEER made a few attachments for his most popular sized socket wrench which enabled him to use it better. These are illustrated in the accompanying drawing. The wrench can be used as a regular socket wrench with the bar through it, as at A. This can be



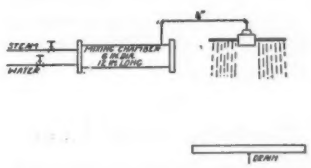
SOCKET WRENCH ATTACHMENTS

extended with the extension B or used with a power air drill with the attachment C. If the handle D is used, the tool can be used on offset angles.

CHAS. H. WILLEY.

A Simple Shower Bath

THE IMPROVISED shower bath shown is well worth the time and slight expense required in making. For a mixer obtain a piece of pipe 5 or 6 in. in diameter and at least 8 in. long, the longer the better. Screw a cap



DETAILS OF IMPROVISED SHOWER BATH

on each end and drill ½-in. holes for steam and water, respectively, and a ¾-in. hole on the top for sprinkler pipe. Use a 2-in. coupling for the center and drill and

tap for ¼-in. spray with cap on each end. The holes for spraying should be about 1/16 in. in diameter. The shower we installed in the power plant was so successful that others were installed in the factory.

SAM BOW.

Preventing Oil Tank Gage From Being Broken

OFTEN we can make improvements on some apparatus in the boiler or engine room to prevent breakage, etc. I have a pressure tank in my engine room used for lubricating the engine cylinder and other steam-using apparatus which needs internal lubrication.

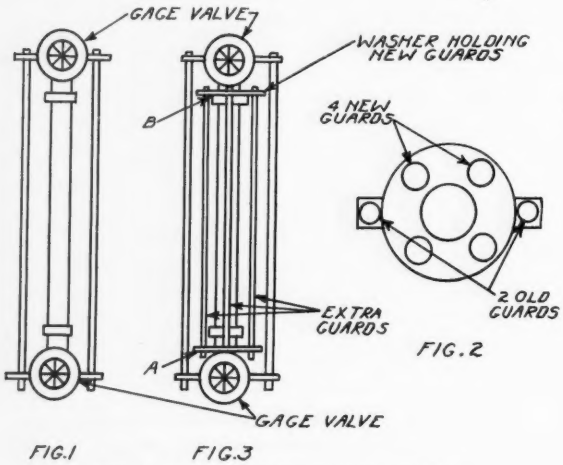


FIG. 1. GAGE GLASS WITH TWO GUARDS
FIG. 2. SHEET IRON WASHER DRILLED TO RECEIVE GUARDS
FIG. 3. GAGE GLASS FITTED WITH FOUR EXTRA GUARDS

The oil gage glass on this tank was equipped with only two guards, as shown in Fig. 1, and quite often the glass which is only 12 in. from the engine room floor was broken when the engine room was swept or scrubbed.

To remedy this trouble I placed four more guards around the gage glass, which was done in the following way. Two washers were cut of heavy sheet iron, four holes drilled along the edge and one large hole in the center as shown in Fig. 2. The gage glass and packing nuts were removed from the gage valves, then one of the sheet iron washers was placed over that part of the lower gage valve which holds the packing nut as shown in Fig. 3 at A. Next the top washer was placed on the top gage glass valve and held there until the gage glass and packing nuts were in place; then the top washer was left resting on the top gage glass packing nut shown in Fig. 3 at B. After that, the four new guard rods were put into the four holes in the washer. After this improvement there was no more breaking of the gage glass accidentally. The last glass that was placed has been in service about 4 yr. H. A. JAHNKE.

Stopping Small Leaks

LEAKS, WHICH are bound to occur at many points around a power plant, are not only a source of annoyance, but often cause appreciable losses. Small leaks are often noticed by the engineer in charge, but due to lack of time or because of their trivial nature, are allowed to continue for days. Such leaks, when they occur at the joints in steam and water lines, are readily stopped without breaking the joints and with no other materials than those which may usually be found in the immediate vicinity. As an example, I have found that the tinfoil from a package of cigarettes or tobacco will stop small leaks very effectively when rolled up and calked into the threads with a light screwdriver. It will make a permanent repair. E. G. M.

Inexpensive Pair of Small Dividers

NECESSITY is the mother of invention. A small pair of dividers is at best an expensive tool when a satisfactory substitute can be quickly made from a broken hacksaw blade. The temper is easily drawn a little to

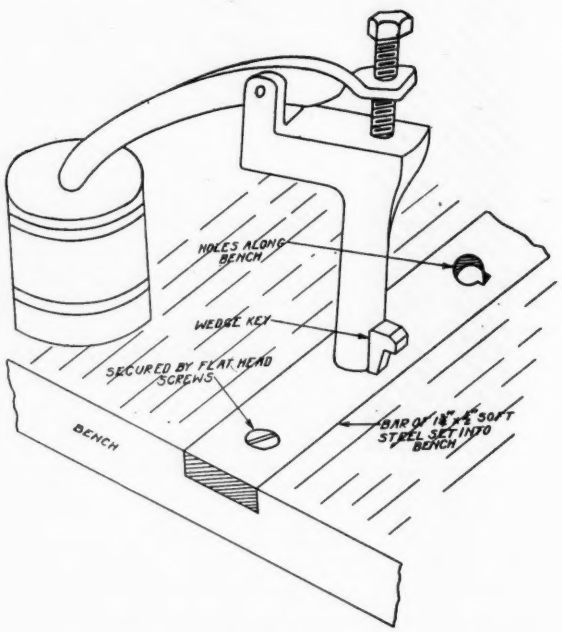
DIVIDERS MADE FROM BROKEN HACKSAW BLADES

grind or file to points. The holes in the ends are perfect for a light rivet. In this manner a few of the odd moments will afford an inexpensive but practical little pair of small dividers.

F. W. BENTLEY, JR.

Easily Constructed Bench Clamp

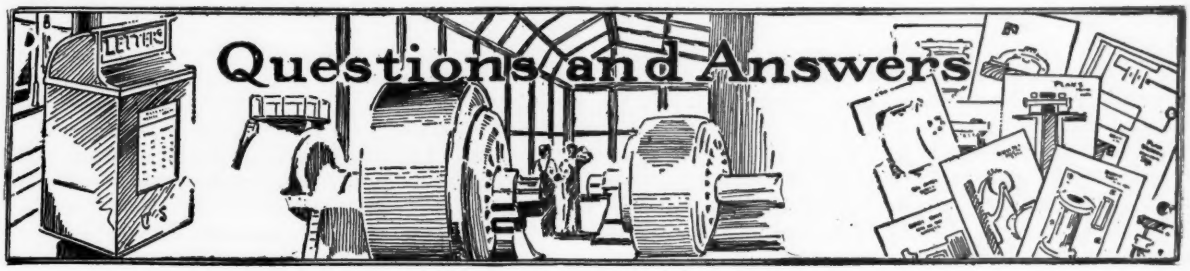
THIS TOOL, illustrated in the accompanying sketch is simple, yet very useful and serviceable and can be made from bar stock by a blacksmith quite easily.



SHOWING METHOD OF USING BENCH CLAMP

The vertical leg is of round stock so that the tool can be swung around to the most convenient position. The sketch tells plainly its use and construction.

C. W.



What Causes These Tubes to Leak?

In connection with letters recently published covering cases of leaky tubes, I am submitting the following for discussion hoping the information will be useful:

A 125 hp. combination horizontal return tubular and water-tube boiler in our plant started to leak in the rear head. The tubes, then 11 yr. old, were renewed as they were too brittle to work over.

These new tubes which have been in service one year have developed leaks three times, have been rolled each time and are starting to leak again.

The boiler is slightly overloaded and the furnace temperature is excessive, a setting lasting only one year. The tubes are cleaned daily, the rear head is free of scale and the breeching is cleaned regularly. Great care is exercised to avoid strains due to cooling at all times.

The return bend was moved, the rear wall moved back 32 in. from rear head and a flat suspension arch installed in place of bend. This was done to stop the scrubbing action of flames on rear head.

Suggestions to remedy this defect will be appreciated.

W. C. B.

How Are Furnace Radiation Losses Determined?

Recently a situation arose where it was necessary to make a determination of the radiation loss through boiler furnace walls. I would like to know, in this connection, what combustion engineers estimate this loss to be. What percentage of the total fuel fired is wasted in making up the loss through uninsulated boiler walls? Take, as a hypothetical case, a boiler operating at 150 per cent rating, having 9 in. of fire brick and 8 in. of common brick as the wall components.

The writer finds that estimates of this loss vary greatly, and would appreciate the views of other engineers on this subject.

C. P. D.

What Causes This Increase in Vacuum?

In my turbine station I have two 500-kw. turbines, with barometric condensers. The problem is, what causes the vacuum to be 2 in. higher in the afternoon on No. 2 machine than it is in the morning? Conditions are just the same as far as load, steam pressure and amount of water handled by condenser are concerned as in the morning. The mill stops at noon for one hour, but we do not shut down, we simply reduce the vacuum to 10 in. Could this condition be due to heating the exhaust pipe during the noon hour, causing it to expand and stop some of the small air leaks that may be in the system? I might say that we have tested for air leaks and found none, and have painted all flanges.

G. L.

Massachusetts Second-Class Engineers' Examination Questions

How do you start a turbine?

2. What is the critical speed of a turbine, and what causes the vibration?

3. How do you equalize the cutoff on a Corliss engine?

4. Do the valves trip on long range Corliss, if set for more than one-half stroke, when the eccentric goes by center?

5. What is the range of cutoff on the single eccentric Corliss?

6. What is the range of cutoff with the non-releasing gear?

7. Does the receiver pressure vary with the steam pressure on a cross-compound engine?

8. Why cannot the speed of the Corliss engine be changed by changing the reach rods?

9. How do you set the valves on the cross and tandem compound engines?

10. Which side do you set first on a cross-compound engine? Why?

11. How are the cranks set on the cross-compound, and why are they so set?

Answers

To warm up, give enough steam so that the turbine will turn over, usually the bypass will give enough steam to keep it going; it should be done this way so that the spindle will warm evenly all around. If you should warm up without turning the spindle around the top would be hot and the bottom cold, which will give unequal expansion.

2. The critical speed of a turbine is usually found somewhere near ¾ of its normal speed, although in some there is no critical speed. Vibration is caused by the rotor being unbalanced, which causes vibrating just before it goes into its actual center of balance; there are other causes of turbines vibrating, but this is the one that is generally considered.

3. Assuming that the valves had been set with the proper lap and that the cutoff had been nearly correct, we would do the rest of the regulating by adjusting the reach rod on one end until the cutoff is equal on both ends.

4. After the eccentric passes its center, the valve cannot trip; but on the long range Corliss the eccentric is usually set less than 90 deg. ahead of the crank. For instance, if the eccentric were set at 45 deg., it would be possible to get about ¾ cutoff, so that with a double eccentric there would be no trouble in getting ½ cutoff or more, up to ¾ stroke.

5. Not later than ½ stroke, for, as the eccentric is set 90 deg. ahead of the crank plus the lap and lead

angles, when the crank gets to 90 deg. the eccentric will be past the dead center and on the return stroke. The Corliss valve must release before the eccentric begins the return stroke, otherwise it will operate the same as a positive motion valve gear.

6. About ¾ stroke.

7. Yes, it will vary as the steam pressure varies.

8. The reach rods are for regulating the cutoff and are used for the sole purpose of moving the cams. The changing of the reach rods will make a slight change in speed, but not enough to be of any consequence.

9. The valves on the cross-compound should be set about the same as on a simple engine, while those on the tandem compound would be set the same except for compression, which should be later.

10. The high pressure side should be set first as this is where the steam starts on its way, and where the speed of the engine is largely controlled.

11. They are set 90 deg. apart so as to give an even turning effort on the shaft.

L. N. W.

Empirical Equations Used in Chimney Design

WHAT FORMULA should be used in designing a chimney for a pair of horizontal return tubular boilers? What factors should be taken into consideration?

R. A. B.

A. The size of chimney to be used for a given boiler installation should be figured from the capacity requirements of the boilers, the amount of flue gases that must be handled and the flue gas temperature. These factors are the draft required, area of the grate, thickness of fuel bed, resistance through the setting, etc.

In practice the particular combination of height and diameter which would be best suited for the installation can not be predetermined with any degree of accuracy because of the uncertainty of various factors entering into the problem.

If specific data are not available for determining these factors, any one of several empirical equations may be used.

These equations are all much alike in a general way and one will probably answer as well as another.

Kent gives these equations:

$$HP = 3.33\ E \sqrt{H}$$

$$H = (0.3 \times HP.)^2 \div E^2$$

$$E = 0.3 \times HP. \div \sqrt{H}$$

In these equations, H is the height above the grate in feet; E is the effective area and is equal to $A - 0.6 \sqrt{A}$, where A is the inside area at the top, sq. ft.; and HP. is the boiler horsepower.

Adams gives the following equations:

$$H = F^2 \div (14A)^2$$

$$A = F \div 14 \sqrt{H}$$

Here, F is the pounds of coal burned per hour. The other factors are the same as in Kent's equations.

Remedy for Burning Soot in Stacks

IT SEEMS unfortunate that W. F. C. has to shut down his plant because of sparks issuing from his smokestacks and dropping on neighboring buildings, as stated in the April 1 issue, page 388. If W. F. C. is burning highly inflammable fuel such as shavings, soft coal, slack or dust, I would advise him to clean out the base of his stacks more frequently. If the soot burns in the stacks it can be mixed in layers with the fuel which he is using and will help save coal provided the necessary draft is on the fires.

Another method which I would recommend, but which should be used only in case of emergency and only when the stacks are cooled down, is to run 1½-in. galvanized pipe from the discharge end of the pump to the top of each stack on the outside. Connect a round circle of perforated pipe at the outlet of the stack. A spray of water issuing from those holes will wash down the soot inside. Of course this method does not prolong the life of the stack, especially a brick stack, as the brick maintains the heat longer. Provision should be made for draining the pipe close to the pump to prevent freezing in cold weather.

If W. F. C. does not desire to follow these instructions and coke, egg, buckwheat and pea coal are available, he should use either grade, as they are not so inflammable and there is little soot.

PATRICK MOLLOY.

Cause of Leaky Flues

FROM THE letters in the April 1 issue of Power Plant Engineering, commenting on my statements concerning leaky flues, in the Jan. 15 issue, it would appear that I had started something.

The sketches shown in connection with my letter were merely for the purpose of showing the path of the gases. They were not drawn to scale and not intended to illustrate the boiler.

I made no notes at the time, but I remember that the boiler was set high above the grates and was in good condition as regards scale. The flues had also been properly rolled and beaded. This boiler was in a contractor's plant where efficiency did not count for as much as reliability of service.

Mr. Vradenburgh says that tubes properly rolled and beaded should remain tight much longer than one year. How much longer the tubes remained tight, I do not know as the plant was later dismantled and I lost track of the boilers.

No records of coal consumption were kept excepting the coal bills so that my statement that less coal was being burned was taken from that source.

In Mr. Carter's letter it is stated that raising the combustion chamber or bridge wall necessarily caused a greater draft, as the gases of combustion had less space through which to pass and therefore caused them to have a higher temperature on reaching the tube sheet.

I did not know that in raising the floor of the combustion chamber I had increased the draft. I had supposed that the area of the flues and the space over the bridge wall would fix the pressure drop through the boiler.

He is correct in saying a reduction in the area of the gas passage would increase the temperature, but my experience has been that the increase occurs where the reduction is made and not 8 or 10 ft. away, as was the case in this installation. The gases reached the back head at too high a temperature and as the larger portion of the boiling is done in the first 18 or 20 in. of the flues, the back end of the boiler was filled with steam bubbles and not solid water.

The change in setting was made to keep the gases in contact with the shell, because the steam jets in the stacks caused a high rate of combustion and made the gases sweep the bottom of the chamber. In so doing the temperature and volume of the gases were reduced before they reachd the back head and more of the heat was given up to the shell.

Perhaps a baffle or wing wall under the rear section of the boiler would have served to better advantage.

C. G. HARDEN.

Work Done by Vacuum Pump

IS IT true that a vacuum pump works harder pulling against a 12-in. vacuum than it does against a 25-in. vacuum? How is the theoretical amount of work done computed in each case? W. F. E.

A. It is not true that a vacuum pump works harder against a 12-in. vacuum than it does against a 25-in. vacuum, provided that the same weight of gas is handled in each case, as the following example will illustrate.

In such a pump or compressor, the work done per pound of air handled may be expressed by the equation

$$W = 4.33\ M.B.T.\ [(p_2 \div p_1)^{0.231} - 1]$$

4.33 being derived from $n \div (n-1)$, in which n is a constant which for isothermal compression would be 1.60, and for adiabatic compression would be 1.40, approximately, or the ratio of the mean specific heat at constant pressure to that at constant volume, but for the purpose at hand where compression is not strictly adiabatic we assume as equal to 1.30; exponent 0.231 is derived from $(n-1) \div n$; M is the weight of the air under consideration, namely 1 lb.; B is what is known as a gas constant which for air is 53.34; T is the absolute temperature in the condenser corresponding to the pressure p_1 and is equal to 647 deg.; p_2 is the initial pressure which for a 12-in. vacuum referred to a 30-in. barometer is 18-in. mercury or 8.85 lb. per sq. in.; and p_2 is the atmospheric or discharge pressure, 14.7 lb. per sq. in.

Evaluating this equation we have $W = 4.33 \times 1 \times 53.34 \times 647\ [(147 \div 8.85)^{0.231} - 1] = 18{,}604$ ft. lb.

With a vacuum of 25 in. in the condenser the pressure is 5 in. mercury or 2.46 lb. per sq. in. and the temperature, T, corresponding, is 593 deg. absolute. The equation is then $W = 4.33 \times 1 \times 53.34 \times 593\ [(14.7 \div 2.46)^{0.231} - 1] = 58{,}981$ ft. lb.

From these results it will be seen that the power required with the higher vacuum is somewhat more than three times as much as is required by the lower vacuum.

Cause of Feed Pump Failure

REPLYING TO A. H. F.'s question on page 340 of the March 15 issue of Power Plant Engineering, I would say that the cause of the cylinder cracking around the end is, in my opinion, slamming at the end of the stroke. This may in turn be caused by an increase in steam pressure accompanied by an increase in pressure on the suction supply line without a corresponding increase of compression. This slamming may or may not occur on both ends of the stroke, depending on what the setting of the valves may be.

The metal of an old casting around stuffing-boxes in pumps will become brittle and if not of extra heavy thickness, may crack as stated. If the casting is in such a condition, it will be necessary to put on a new cylinder or perhaps put in a new pump. Many bolts are broken by screwing up the nuts on the follower hard against old hard packing. Calipers should be used on pumps of such size as a variation of 1/16 in. in the setting up of the gland would cause it to rub against the plunger, and wear a shoulder there. With the shoulder on the plunger, any change in valve adjustment which would cause the plunger to travel further toward the follower gland, would cause this shoulder to strike the edge of the follower gland, breaking both it and the bolts. It might also pull a strong bolt out of the casting and in doing so crack the casting.

Careless use of a monkey wrench in tightening the nuts while running has been the cause of many bolts becoming bent as the crosshead jammed the wrench in against them.

The length of the piston stroke is always increasing with wear on the valve and tappets or links, and in taking up this wear many men have met with the same trouble by not keeping the piston traveling in the same portion of the cylinder.

Had I reason to believe that the plungers were worn, I should try a pair of calipers all the way around the plunger, which would show if it had become worn off on any one side where the stuffing-box gland had been rubbing. Finding this to be the case, I would so change the piston stroke that its travel toward the stuffing-box would be shorter which would prevent the shoulder from striking until such time as the plunger could be taken out and turned up true in a lathe. R. A. CULTRA.

Selecting the Prime Mover

IN A new electric generating plant it has been decided that we use a horizontal reciprocating engine. Should a simple or compound engine be used? Which is generally considered to be the better suited for this class of work, i. e., where electric power is the only product?

E. B. F.

A. It is to be assumed from your statement that an engine must be used, that the turbine has been discarded.

If no use can be made of exhaust steam and if there is plenty of cooling water available at a low cost, a condensing unit would invariably be the choice, and the type of engine that would give the best overall economy under these conditions should be selected. Generally speaking a compound engine would be used.

Other considerations may, however, influence the choice. Without knowing, then, all the conditions of operation, a fair decision can not be made. Below is a general list of the advantages and disadvantages of the compound engine which would have a bearing on the ultimate award:

ADVANTAGES

High range of expansion permissible.
Cylinder condensation decreased.
Clearance and leakage losses decreased.
Crank effort equalized.
Steam consumption reduced.

DISADVANTAGES

First cost increased due to multiplication of parts.
Increased bulk.
Increased complexity.
Increased wear and tear, and maintenance cost.
Radiation losses multiplied.

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Standardization to Reduce Costs

Although it is important that every piece of apparatus in a plant be suited to the work it is to do, which in some cases involves special design and construction; and while standardization of power machinery has been well advanced, there are yet some lines where reducing the varieties of styles and adopting a common standard would result in lower costs of manufacture, hence lower cost to consumers. What can be accomplished in reducing costs both of making and installing equipment is well illustrated by the standard pipe fittings, now universally used; and progress has been made in nearly every line of power plant equipment looking toward like results.

In specialties, of course, standardization is not possible except as to connections, for each has its particular features, but reduction of types and sizes to those really needed may offer a field for economies which will result in benefit to the industry.

Gains come from having less capital tied up in raw materials, partly finished and finished stocks of goods, jigs, dies and special machinery, storage space and spare parts. Greater production is possible because of fewer changes in machine-tool setting, longer and steadier runs, less inspection and stock keeping, lower cost of waste and experimenting. Employes become more proficient when working on a less variety of parts and better service can be given on repairs.

For the buyer, standardization and simplification permits better comparison of various makes of apparatus, makes the planning for enlargement or rearrangement of plants easier, cuts the cost of installation, overhauling and replacement and reduces the cost of emergency spare parts to be carried.

While it may require courage to tell a sales force that they are to have a less variety of goods to offer, those who have tried it find that it is a wise policy to cut out unnecessary sizes and lines for which there is little demand and concentrate on those which are widely used. The work of the Bureau of Standards of the Department of Commerce, and the efforts of the Fabricated Production Department of the Chamber of Commerce of the United States have helped many individual manufacturers and trade associations to make decided progress in this direction, and the results obtained are well worth investigation by those seeking to eliminate waste and increase efficiency.

Go Back to Principles

Too frequently we do things in the power plant according to instructions without much thought as to why it is done just that way except that we are following explicit instructions and that we get the desired results. The fireman is given orders to maintain certain drafts in his furnace and windbox for specific loads carried on the boiler. When he does this well, his lesson has been learned and little more pains are taken to point out to him just why these variations give better results.

Oilers are told that a certain brand of oil is to be used for the steam cylinders, another for engine and generator bearings, while another must be used on turbine bearings. In answer to any questions he may ask,

he is likely to receive the reply that best results are obtained by using the oils specified.

When any new piece of apparatus is put into a plant there is usually a set of rules tacked up on the wall nearby giving directions for starting, stopping and care of the equipment, and frequently a set of don'ts follow the regular rules for operation. All these instructions are good and necessary but it is not likely that they can cover every situation which might arise in the operation of the apparatus and those who are responsible for the equipment in the plant should make clear the reasons for each rule laid down in the plant, thus preparing the men to meet emergencies not covered by rules.

It would be possible to cite numerous cases where workmen are usually given orders rather than instructions and when in an emergency they must depend upon their own judgment serious mistakes are made because the principles underlying their work have not been thoroughly understood.

Probably the natural laws used in the power plant which are most difficult to understand are those dealing with chemical changes and for this reason many things take place in the power plant which are mysterious to the average man. Take for example the chemistry involved in the treatment of water for boiler feed purposes, and we encounter reactions and double reactions, the equations for which comparatively few men in the power plants of the country would attempt to write out with any degree of certainty that they are right.

The method of testing water by titration gives rapid and accurate results even when the test is performed by a man who is not familiar with the chemical changes involved, yet any engineer who notes the changes in the character of the water in the Schuylkill River, as given by Messrs. Joos and Binns on other pages of this issue, can readily appreciate the importance of a knowledge of the chemical changes which take place not only during the process of titration but also while the water is undergoing treatment. This series of two articles on boiler water is intended to give the reader a working knowledge of the process of water treatment and aid in the operations of boilers by going back to first principles.

Abating the Smoke Nuisance

Notwithstanding the remarkable progress which of late years has characterized the art of stoker and furnace design and the advances made in methods of burning coal, our industrial centers are still more or less conspicuous because of the large volumes of smoke issuing from the stacks of their power plants. In the larger cities where stringent smoke ordinances are enforced, the atmosphere has to some extent been cleared of the obnoxious element but there are still many localities where practically no effort is made to prevent its production.

Experience has shown that with good modern equipment—well designed furnaces and suitable stoking equipment—the production of smoke can be reduced to a negligible quantity. And, since smoke, in addition to being a nuisance to the community is generally also an indication of inefficiency, the larger plants have seen fit to install such modern apparatus as would eliminate smoke and its consequent waste of fuel. Many of the smaller plants, however, are still operating under conditions conducive to the production of smoke.

There is no particular reason, however, why a small plant cannot eliminate the production of smoke as well as a large plant by the use of suitable equipment. This does not mean scrapping the entire plant and installing new equipment, but merely the making of a few simple changes in the furnace construction or in the design of the grates. As an illustration of what may be accomplished along this line, the reader is referred to the article in the current issue by R. R. Hillman. Mr. Hillman describes a specific case, but the method of solution is one which, no doubt, can be applied in almost any similar case where the smoke nuisance is to be eliminated.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.
Develop Water Power Sites.
Promote Health and Safety in Power Plants.
Handle Coal and Ashes Mechanically.
Employ Engineers for Engineering Work.

When You Move Notify the Post Office

MANY PEOPLE who change their place of residence at this time of the year do not advise the post office of their new address and, as a result, valuable letters and parcels addressed to them are delayed or fail of delivery.

You should be sure, if you have changed your residence or contemplate such a change, to notify the post office promptly either by dropping a card, giving both the old and the new address, in the nearest mail box or by giving your new address to the letter carrier, who has cards especially provided for that purpose.

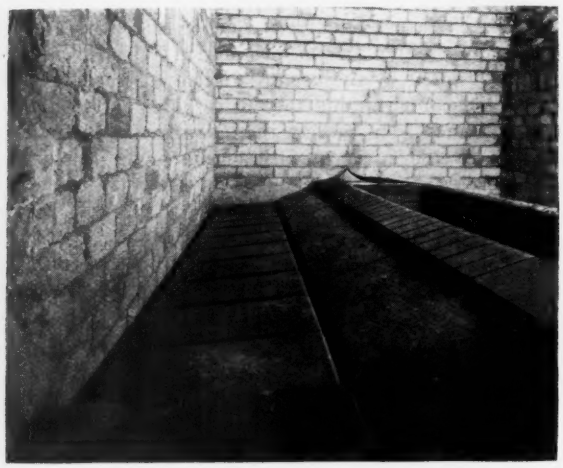
Also be sure to notify all publications to which you subscribe so that the mailing address may be changed and your copies reach you regularly and promptly.

INVESTIGATIONS CONDUCTED at the Northwest Experiment Station of the U. S. Bureau of Mines at the University of Washington, Seattle, show that there is no reason, technically, why many American coals cannot be successfully cleaned of part of their ash and refuse by froth flotation, a process already in extensive use in cleaning or concentrating copper, lead, and other ores. Particularly on the Washington State coals investigated, much ash not ordinarily removed by the present form of cleaning jigs is capable of elimination. The process has already been put into successful commercial practice in England and in other foreign coal fields. Its commercial success in this country must, of course, depend on its cost as compared with the present cost of putting clean coal on the market. It would appear, however, that the process offers promise, especially in coal fields where the product coming from the mines contains high ash, and where competition from clean coal from other fields is not too great. For the future, when it becomes imperative to mine the dirtier beds of coal, it points the way to greatly increasing the nation's potential coal supply.

Side Dump Underfeed Stoker

THERE HAS been recently brought out by the Under-Feed Stoker Co. of America, the Jones standard side-dump stoker, the design of which is in a large degree similar to the stokers previously made by this company, but which embodies in addition hand-operated side dump grates which are fairly well illustrated in the accompanying illustration.

The stoker is self cleaning and consequently a marked saving in labor is possible. Successive strokes of the steam driven ram moves the coal to the rear and upward as it undergoes the different stages of combustion.



SIDE DUMP FEATURES OF JONES UNDERFEED STOKER

Ash and clinker are finally deposited on the side dump plate and are dropped from there into the shallow ash pit below. These dump plates are operated at intervals of from 2 to 6 hr., depending on the ash content, the rate of firing, and the firing characteristic of the coal burned.

The ash is raked out from the pit, after it has cooled, through the ash pit door. There is practically no loss of draft or chilling of the fire during this operation.

An air blower used in connection with this stoker is regulated as to speed by the boiler pressure as is also the stoker engine. This parallel regulation of both air and fuel results in a constant relation between the two, a fact which tends towards better combustion efficiency.

The Ray Elastic Disc Expansion Joint

THE DEVELOPMENT of the Ray Elastic Disc Expansion Joint, shown in the accompanying illustration, is of particular interest to those having had experience with the design or operation of long pipe lines. That pipe lines undergo variations in length due to changes in temperature is only too evident from the destructive effects which manifest themselves in cases where no provision is made to compensate for expansion. The new Ray Electric Expansion Joint was designed to compensate for such expansion and at the same time provide an absolutely tight joint.

As is seen from the illustrations, the joint consists of two flanges connected together by means of a flexible element, the flanges being guided relatively to each other so as to permit longitudinal movement while preventing lateral movement. The longitudinal movement of the flanges is secured through the bending of the metal of the flexible element. The elastic element of this joint, shown in Fig. 2, consists of a number of corrugated steel discs alternately welded together at their inner and outer circumferences, the end disc being provided with enlarged flanges for attaching to the flanged end pieces. The discs are pressed from plates

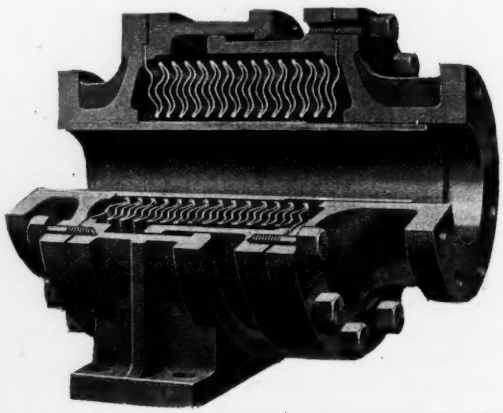


FIG. 1. PART SECTIONAL VIEW OF RAY ELASTIC DISC JOINT

of crucible nickel steel, which, when subjected to the particular heat treatment given the completed element, has an elastic limit of approximately 170,000 lb. per sq. in. and an ultimate strength of about 220,000 lb. combined with great toughness or resiliency.

The elastic element is entirely complete in itself and distinct from the other parts of the joint. The method of connecting the elastic element to the flanged end pieces is clearly shown in the illustration, Fig. 1, and it may be seen that the two flanged end discs of the elastic element are securely held between heavy male and female flanges of the end pieces, suitable gaskets

FIG. 2. THE ELASTIC ELEMENT

being used to prevent leakage. This method of connection to the elastic element is of importance as it not only allows the element to be removed and replaced readily but it also permits every weld in the elastic element to be subjected to identical working conditions and eliminates the concentration of stress which would otherwise result from the rigid attachment of the flexible discs to the end pieces.

Referring to Fig. 1, it will be seen that the outer casing used not only serves as a protecting covering for the discs and a foundation for heat insulating covering, but also acts as a stop for the movement of the joint in both directions, thus preventing the movement of the elastic element from exceeding the elastic limits under any conditions of use or even unuse. There is also a heavy tube inside of the elastic element one end of which is forced into one of the flanged heads, the other end making a close sliding fit with the other movable head in a true axial line. In addition to acting as a guide this tube also will prevent the escape of any considerable amount of steam in case of breakage of the elastic element, due to any unforeseen or accidental

FIG. 3. ACTUAL PHOTOGRAPH OF A TYPICAL WELD IN THE ELASTIC ELEMENT

cause. This tube furthermore protects the elastic element from water hammer and the entrance of foreign bodies between the discs.

The end flanged pieces are made of cast iron for low and standard pressure, and of cast steel for high pressures with superheat. They are provided with standard or extra heavy flanges as required with suitable drilling for through bolts, etc.

Power Plant Materials

FROM the Survey of Current Business issued by the Department of Commerce are obtained figures which give the trend of the markets for materials used in the construction of power plants and the machinery for equipment. The Survey covers all fields of business, but the data of special interest to those engaged in the power plant industry are as follows:

Compared with prices in 1913, the per cent wholesale prices for February, 1922, were: on hides, 90; on chrome leather, 170; on bituminous coal, 160; on coke, 125; on pig iron, 125; on steel billets, 105; on steel beams, 100; on copper, 80; on lead, 105; on tin, 70; on zinc, 80; on brick, N. Y.—250, Chicago—160; on cement, 150; on rubber, 20; on sulphuric acid, 80 per cent.

Some figures which show the trend of business in recent months are also given. Production of bituminous coal increased for February over January, 1922, due to the effort to accumulate a surplus before the strike went into effect, the total for the two months, January and February, 1922, being 10.4 per cent greater than for the corresponding months of 1921. Prices for February were slightly less than for January and were 30 per cent less than for February, 1921. Production of anthracite increased slightly for February over January, but the total for the two months of 1922 was 13.8 per cent less than for the same months of 1921, the price being about 90 cents a ton less for domestic sizes.

Petroleum showed for February a decline in production from the January figures of 2000 bbl, but was 6200 bbl. greater than for February, 1921. The consumption was 4300 bbl. greater than for January, 1922, and 1600 bbl. greater than for February, 1921. The price was the same as for January, but was $0.31 less per bbl than for February, 1921.

Power supplied by public utility companies showed a decrease from January figures as would always be the case on account of the lengthened days, but there was an increase over February, 1921, the total for January and February being 8.5 per cent greater for 1922 than for 1921.

Of the two materials chiefly used in power machinery, iron and steel showed little change in production either as between months or between years, but copper production was 61.1 per cent less for January and February, 1922, than for 1921. The price of pig iron was $9 to $10 a ton less for February, 1922, than for February, 1921, and steel beams were about $1 per 100 lb less, while copper was $0.007 per lb. less than in 1921.

Building construction showed for the first two months of 1922 over 1921 a gain of 87.7 per cent in floor area and 61.9 per cent in value, all classes of buildings participating in the increase. But the lamentable fact is that the losses of buildings by fire was greater than the value constructed, even with the increased rate of building. Production of fire brick declined 31.5 per cent for the two months of 1922 over 1921, but face brick production increased 45.6 per cent. Prices for common brick in New York showed practically no change, but for Chicago the price for 1922 was about $2.88 less in 1922 than in 1921. Cement production was practically unchanged, but the price for 1922 was about $0.25 a bbl. less than for 1921.

About 5,000,000 lb. more of belting leather was sold in January, 1922, than for January, 1921, but the sales of belting were 14,000 lb. less. Prices for sole hemlock middle No. 1 were 1c per lb. more for February than for January, but were 3c per lb. less than for February, 1921.

Study of the figures shows that the materials which enter into the construction of machinery are for the most part readjusted nearly or quite to a prewar basis, but leather, fuels, brick and cement are still high, though showing a decrease from last year. Prices for these commodities have been fairly steady for the last 4 mo, but with a slight upward turn recently.

A NEWLY discovered coal field is reported in Shantung Province, which is said to contain an immense quantity of smokeless coal. Chinese and foreign engineers were engaged in the exploration of the coal field, and the mine is to be developed under Chinese auspices at an expenditure of $500,000.—Compressed Air.

Program for A. S. M. E. Spring Meeting

ARRANGEMENTS are now completed for the spring meeting of the American Society of Mechanical Engineers which will be held on May 8 to 11 in Atlanta, Ga., the headquarters being at the Piedmont Hotel. Registration opens on Monday morning and there will also be a meeting of the Council during the morning hours. In the afternoon a general business meeting will be held and in the evening the members and guests will be given an informal get-together dinner at the Piedmont Hotel.

Tuesday morning's sessions will begin at 9:30 with a public hearing on the Power Test Codes followed by three simultaneous sessions. At the textile machinery session, S. E. Gillespie will read a paper on Cotton Ginning Machinery, and E. H. Marble one on Maintenance of Textile Machinery. The material handling session will be given over to a paper entitled Material Handling Equipment as Used in the Iron and Steel Industry by F. L. Leach. In the general session, the following papers will be read: Accuracy of Boiler Tests by Alfred Cotton, and Turning Exhaust Losses Into Work in Reciprocating Engines by J. Stumpf and C. C. Trump.

The afternoon of Tuesday will be given over to excursions to points of local interest and in the evening a dance will be held in the Ansley Roof Garden.

Three simultaneous sessions will be held on Wednesday. At the textile machinery session, L. B. Jenckes will read a paper on Weaving Machinery, Joseph Davidson on Extraction of Oil from Vegetable Matter, and F. E. Banfield, Jr., on Modern Shop Practice in the Building of Revolving Flat Cars. The papers to be presented at the fuels session are as follows: Reduction of Fuel Wastes in the Steel Industry, by F. G. Cutler; The Control of Boiler Operation, by E. A. Uehling; and Boiler Room Performances and Practice at Colfax Station, Duquesne Light Co., by C. W. E. Clarke. The titles of papers to be read at the general session are as follows: Centrifugal Castings, by Leon Cammen; The Muscle Shoals Nitrate Plant and The Nitrogen Supply, by Maj. J. K. Clement; Insulation Losses from Pipe Coverings, by R. H. Heilman; and Evaporation of a Liquid Into a Gas, by W. K. Lewis.

In the afternoon, a barbecue will be given and a golf exhibition match will be held at the East Lake Country Club. In the evening, an informal dinner will be given in the Ansley Roof Garden.

Three simultaneous sessions will be held on Thursday morning, the management session being given over to papers entitled The Southern Worker—His History and Character, by F. H. Neely, and Management Applied to Textile Plants, by George S. Harris. At the power session, the following papers will be read: Power Development in the Southeast, by Chas. G. Adsit, and Economics of Water Power Development, by C. A. Mees; New Developments in Hydroelectric Design, by John A. Sirnit; and Report Upon Efficiency Tests of a 60,000-kw. Cross-Compound, Triple-Cylinder Steam Turbine, by H. B. Reynolds and W. F. Hovey. The third session will be a symposium on welding, the papers to be presented being as follows: The Strength of Electrically Welded Pressure Containers, by R. J. Roark; Some Principles of the Construction of Unfired Pressure Vessels, by S. W. Miller; Steel for Forge Welding, by F. N. Speller; and Tests on Welded Cylinders, by E. A. Fessenden and E. J. Bradford. The afternoon will be given over to a theater party and the evening will be left free for individual conferences.

Coal Production Reaches Lowest Record

ACCORDING to a report issued April 8 by the U. S. Geological Survey, the total production of coal, including anthracite and bituminous, reached the lowest point in modern coal history during the first week of the strike which has been carried on since April 1. The output of bituminous coal dropped to approximately 3,500,000 T. during the week ending April 8, or about ¼ the production of the previous week. In the anthracite region, work ceased entirely.

The reports show that from 60 to 64 per cent of the bituminous tonnage of the country has been closed by the strike. Of the remaining tonnage a significant portion had not been operating recently for lack of demand. In the first week of the 1919 strike, 71 per cent of the tonnage was closed. The smaller portion closed during the present strike is partly explained by the fact that certain organized districts whose contracts did not expire on April 1 have continued to operate.

The following statement shows the cars of soft coal loaded daily, according to telegraphic reports received from the carriers. As April 1 is a union holiday, loadings on Saturday did not reveal the extent of the strike. The first test came on Monday, April 3. On that day 11,445 cars were loaded, against 38,056 cars on the preceding Monday. Monday, April 3, 11,445 cars; Tuesday, 11,019; Wednesday, 11,411; and Thursday, 11,061 cars.

Returns received at the time the report was issued for Friday, April 7, indicated little change, and the total output for the week was estimated at 3,500,000 T. In the first week of the 1919 strike 3,582,000 T. were produced.

The week's output falls short of what the mines not affected by the strike can produce if the demand is active. From mines in many non-union districts reports of "dull market," and "no orders" had been received, and there was a large number of loaded cars unbilled on the sidings, some of which were in fields closed by the strike.

The record of production during March removed all reasonable doubt that the 52,500,000 net tons of soft coal in the hands of consumers on March 1 had increased to 63,000,000 T. or more, by the opening day of the strike. The quantity on hand on April 1 was, therefore, equal to the maximum stock at the end of the war.

At the rate of consumption prevailing in January and February, the reserve in the hands of consumers, April 1, was sufficient to last 52 days, if evenly divided.

But stocks are never evenly divided. There are some consumers who store virtually no coal, and in some entire states the average stock is much lower than in others. Further, a certain minimum reserve is necessary for steady operation of utilities and industrial plants.

Back of this stock of 63,000,000 T. in the hands of consumers, April 1, there was a further reserve of over

4,000,000 T. on the upper lake docks, and a smaller quantity stored on the ground at the mines or at intermediate storage yards. These figures take no account of the coal on wheels, including a heavy tonnage of unbilled loads on hand at the mines when work stopped in the union districts on Saturday.

Anthracite is stored commercially in three places—in retail coal yards, on the upper lake docks, and in the storage yards of the producers. Retail coal dealers' stocks on March 1 were about the same as a year ago, but much larger than in 1919 and 1920. Stocks on the lake docks were 821,000 T. on the same date. No statistics of anthracite in producers' storage are available for March 1. On Nov. 1 last, there were 4,500,000 gross tons in the yards, of which 40 per cent was domestic sizes.

In addition there is a surplus of 1,000,000 T. of coke on hand at by-product coke works, much of which may be considered a substitute for anthracite.

Fire Destroys Union Iron Works Building

ON THE night of March 23 fire broke out in the main factory building of the Union Iron Works at Erie, Pa., and in spite of all precautions that had been taken to prevent such a loss and the strenuous efforts of the fireman, the main building was completely destroyed. This building had been erected in sections, as the growth of business over a period of more than 20 yr. demanded, and represented various types of construction ranging from brick with wooden window frames and roof trusses to all brick and steel. The main part of the building was 70 ft. wide by 600 ft. long and the ell connected to it was 100 ft. wide by 250 ft. long.

Although the origin of the fire is not known, indications are that it started in the riveting tower, about the middle of the plant. Here the old type wooden timber construction was employed and, due to the heat from the rivet forges, was thoroughly dried out.

While the loss of this main building was serious, it is covered by insurance and the factory still has a complete stock and tank house, a complete flanging department, blacksmith shop, casting department, warehouse, storehouse, power house and office. In the buildings which remain, work will proceed without interruption and but slight delay.

Steps have been taken to rebuild immediately, the new building having already been determined upon as to size and character.

News Notes

THE PENNSYLVANIA PUMP & COMPRESSOR CO. has opened an office in Chicago under the management of H. M. Montgomery, the address being 105 West Monroe St.

THE DUQUESNE LIGHT CO., of Pittsburgh, has recently authorized Dwight P. Robinson & Co. to install two additional boilers of 22,914 sq. ft. of surface and to design and construct extensive additions to the company's high tension sub-stations.

INTERNATIONAL FILTER CO. has moved its general offices in Chicago from the First National Bank Building to 327 W. 25th St.

ANNOUNCEMENT has reached us of the "Informashow," the official exposition of the National Association of Purchasing Agents, which is to be held at Rochester, N. Y., May 15 to 20, 1922. This is to be a convention and exhibition, and is so named because the character of the exhibits is such as will serve to demonstrate the importance of the consideration of values in the determination of purchases.

WHITING CORPORATION has moved its Chicago sales office from 1245 Marquette Bldg. to 945 Monadnock Bldg.

THE MCCLAVE-BROOKS CO. has appointed the Steam Plant Equipment Co., Kansas City, Mo., as its representatives in that territory.

THE FLEXIBLE STEEL LACING CO., of Chicago, has just placed on the market a new size of Alligator steel belt lacing known as No. 1. This is for tape belts ranging in thickness from 1/16 to 3/32 in. and is made up in 6-in. sections.

COMBUSTION ENGINEERING CORPORATION completed arrangements whereby, on March 1, the Power Plant Equipment Co., of Kansas City, Mo., became the representative in that territory which covers, in a general way, eastern Kansas, eastern Nebraska, western Arkansas and western Missouri.

THE PATTERSON-KELLEY CO., formerly located at 26 Cortlandt St., New York, has removed its offices to the Architects Building, 101 Park Ave., New York, as it is thought that this more central location will permit serving customers, both local and out of town, much more promptly, conveniently and efficiently.

DURING THE LAST THREE months there have been a number of changes in the sales organization of the Celite Products Company. Branch offices have recently been established in Boston, Buffalo, Cincinnati, and Minneapolis. F. W. Emerson has been placed in charge of the Boston office, W. D. Van Arnam is district manager for Buffalo territory, L. M. Lindsey is in charge of the Cincinnati office, and E. R. La Belle is at Minneapolis. A change has also been made in the New Orleans office which places J. C. Etheredge as district manager for this territory.

THE TENNESSEE COAL, IRON & RAILROAD CO. has just closed a contract with the Fuller Engineering Co. for the installation of the complete coal drying, pulverizing and conveying systems to serve its plant at Ensley, Ala.; also the burners and feeders for five 834-hp. Stirling boilers designed to operate at 200 per cent of rating.

The boilers will be situated approximately 600 ft. from the pulverizing plant and the fuel will be conveyed directly from the pulverizer to the boiler bins. The fuel will be diverted from the main line to the individual service bins through distributing valves and branch lines. The bins will be equipped with automatic bin indicators which will keep the operator advised at all times as to the fuel conditions in the service bins.

C. E. JOOS, formerly with the Atlantic Refining Co. in the capacity of water treatment engineer, has recently become associated with Cyrus Wm. Rice & Co., of Pittsburgh, as chemical engineer specializing in water treatment.

THE U. S. CIVIL SERVICE COMMISSION is authority for the statement that of late an average year's business of the U. S. Patent Office consists of more than 85,000 applications for patents, and that more than one and a quarter million patents have been issued since the present system was established by the act of 1836.

Each division of the Patent Office passes on distinct subjects of invention. Whether the invention pertains to a hairpin or a cantilever bridge, a perfume or a deadly gas, a process of mounting jewels or for extracting and refining metals, a new toy or a new engine of destruction, there will be found in the Patent Office experts possessed of the requisite knowledge to understand the invention, its operation and the field occupied by similar attempts.

The Civil Service Commission states that it will hold examinations on May 10, 11 and 12, and on June 21, 22 and 23, throughout the United States, to secure eligibles to fill vacancies in positions of assistant examiner in the Patent Office. The entrance salary offered is $1500 a year, plus the bonus of $20 a month granted by Congress, and there is provision for promotion on merit to positions paying from $1650 to $3900 a year. Technical training is necessary.

Full information and application blanks may be secured from the U. S. Civil Service Commission, Washington, D. C., or the civil service board at the post office or customhouse in any city.

Catalog Notes

LOPULCO PULVERIZED FUEL SYSTEM FOR LOCOMOTIVES, a bulletin recently issued by the Combustion Engineering Corp., contains, besides a description of the apparatus, some interesting data on comparative tests made on locomotives equipped for both pulverized coal and hand-firing. Results of these tests are plotted against each other so that comparisons may be readily made.

"NATIONAL" BULLETIN No. 16D, Manufacture and Advantage of "National" and "Shelby" Boiler Tubes, contains 14 pages of description and illustrations, with tables of properties and pressures. The maker is National Tube Co., Pittsburgh, Pa.

RECENT PUBLICATIONS of the Simplex Valve & Meter Co., of Philadelphia, have been received, as follows: Bulletin 30, entitled, Water Waste Surveys, and Bulletin 32, How Much Water Do You Convert into Steam with the Coal You Buy?

SAFETY SWITCHES and Panel Boards is the subject of Catalog 12-A which is now being distributed by the Westinghouse Electric & Mfg. Co. This catalog is profusely illustrated with views of installations of safety switches in the shop, in the office, and in the home. Dimensions and list prices of these switches are given in detail. Some of the subjects that are discussed are the railway type safety panel boards, the safety car lighting panels, the auto-lock control panels, the dead-front and dead-rear safety switchboards, the live-front knife switches and many other deviees.

DESCHANEL CABLEWAY BULLETIN, lately published, describes the Deschanel cableway, with which material, such as coal, can be unloaded direct from railroad car or barge into storage, and reclaimed again for further transportation to the power house, and ashes can be removed from the boiler room to cars or storage pile without necessitating further change in the equipment. The manufacturer is Deschanel Engineering Corporation, New York.

BOOK OF VIEWS showing recent work done by Cement Gun Construction Co., Chicago, was lately received from that company.

BULLETIN 10 from Thwing Instrument Co., Philadelphia, deals with Thwing thermo-electric pyrometers, indicating and multiple-recording types.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for April 1, 1922.

State of Illinois } ss.
County of Cook }

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, none.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
A. E. Rice, Wilmette, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 25th day of March, 1922.

(SEAL) Gertrude M. Williams.

(My commission expires Aug. 12, 1925.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.